ENGINEERING LIBRARY
MAR 2 1950

APPLIED HYDRAULICS

The Magazine of Fluid Power Transmission

NE, 1949

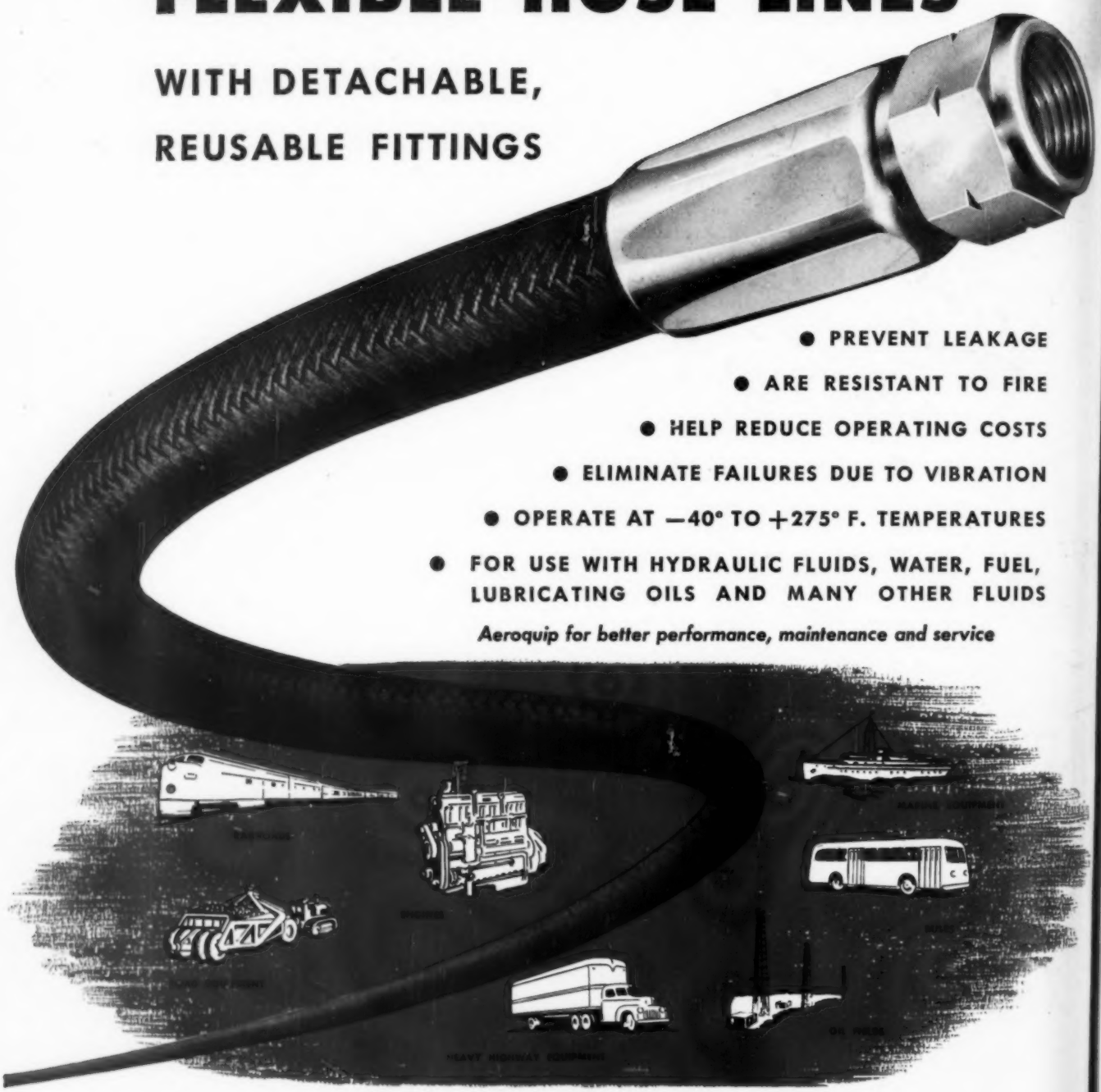
- HYDRAULIC CIRCUITS
- HYDRAULIC CONTROLS
- R CIRCUITS
- R CONTROLS
- LECTRICAL AND LECTRONIC CONTROLS

HENRY M. WOOD CO.

Aeroquip

FLEXIBLE HOSE LINES

WITH DETACHABLE, REUSABLE FITTINGS



- PREVENT LEAKAGE
- ARE RESISTANT TO FIRE
- HELP REDUCE OPERATING COSTS
- ELIMINATE FAILURES DUE TO VIBRATION
- OPERATE AT —40° TO +275° F. TEMPERATURES
- FOR USE WITH HYDRAULIC FLUIDS, WATER, FUEL, LUBRICATING OILS AND MANY OTHER FLUIDS

Aeroquip for better performance, maintenance and service

Dealers and Distributors Wanted

AEROQUIP CORPORATION

JACKSON, MICHIGAN

SALES OFFICES AND WAREHOUSES: 1053 NO. HOLLYWOOD WAY, BURBANK, CALIF. — 1215 SO. EAST GRAND AVE., PORTLAND 14, ORE. — 2912 N. E. 28TH ST., FORT WORTH 11, TEXAS — 72-74 STAFFORD STREET, TORONTO, CANADA

SALES OFFICES: 303 WAREHAM BLDG., HAGERSTOWN, MD. — 1419 2ND AVE., SO., MINNEAPOLIS 4, MINN.

AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U. S. A. AND ABROAD

JUNE, 1949

Vol. 2 No. 5

APPLIED HYDRAULICS

The Magazine of Fluid Power Transmission

IRVING B. HEXTER, Pres.
LESTER P. AURBACH, V. Pres.
JEROME H. PESKIN
General Manager
PAUL L. REED
Editor
R. W. EISENTHALER
Associate Editor

Production Department
WILLIAM V. LINAS
Director

Circulation Department
E. C. HEXTER
Director

Editorial and Business Office
1240 Ontario Street
Cleveland 13, Ohio
Phone: Tower 1-0264
AT&T Teletypewriter Number is CV-233

NEW YORK OFFICE
STEPHEN SHEPHARD
19-25 W. 44th Street
Room 412
New York 18, N. Y.
Murray Hill 7-3420

CHICAGO OFFICE
M. A. BROWN
64 East Lake Street
Room 1013
Chicago 1, Illinois
Andover 3-4972

LOS ANGELES OFFICE
FRED W. FRISENHELDT
Industrial Publishing Co.
Room 403
1250 Wilshire Blvd.
Los Angeles 14, Calif.
TUcker 6703

The Hydraulics Publishing Company is affiliated with the Industrial Publishing Company which also publishes the following magazines:

FLOW
DIE CASTINGS
INDUSTRY & WELDING
THE TAXICAB INDUSTRY
OCCUPATIONAL HAZARDS
COMMERCIAL REFRIGERATION AND AIR CONDITIONING

Subscriptions

By the year	$3.00
Two years	$5.00
Three years	$6.50
Single copy	30 cents
Canada	$4.00
Two years	$6.00
Foreign	$5.00

Copyright 1949 by The Hydraulics Publishing Co.

FRONT COVER: Two of the Air Force's latest jet propelled airplanes. The F-86, foreground, is the fastest single seat fighter in regular squadron operation; the B-45, rear, is the new four jet engine light bomber. The latter utilizes nearly one hundred hydraulic components for power and control operations. Both planes are in production by North American Aviation, Inc.

—Photo, courtesy, USAF Air Material Command

CONTENTS

Editorial—Gold Brick . . . Or The Real Thing? 9

The Air-Powered Hydraulic Circuit 10
By Clarence Johnson

Announcement of Aviation Hydraulics Section 13

BASIC HYDRAULICS SECTION
A Beginner's Course in Basic Hydraulics, Part I, Chapter II 14

Eggs, Over Lightly 18

AVIATION HYDRAULICS SECTION
Aircraft—A Challenge to Hydraulics 20
By Fred O. Hosterman

SAE Aeronautical Standards Program 22
By J. D. Redding

Homebrew Circuits for Manufacturing Novelties 32
By John B. Hill, Jr.

DEPARTMENTS

LETTERS TO THE EDITOR 25

USEFUL LITERATURE 26

MAINTENANCE SECTION
Hydraulic Maintenance of Machine Tools, HM-8 29

NEW PRODUCTS 31

APPLIED HYDRAULICS DIGEST 37

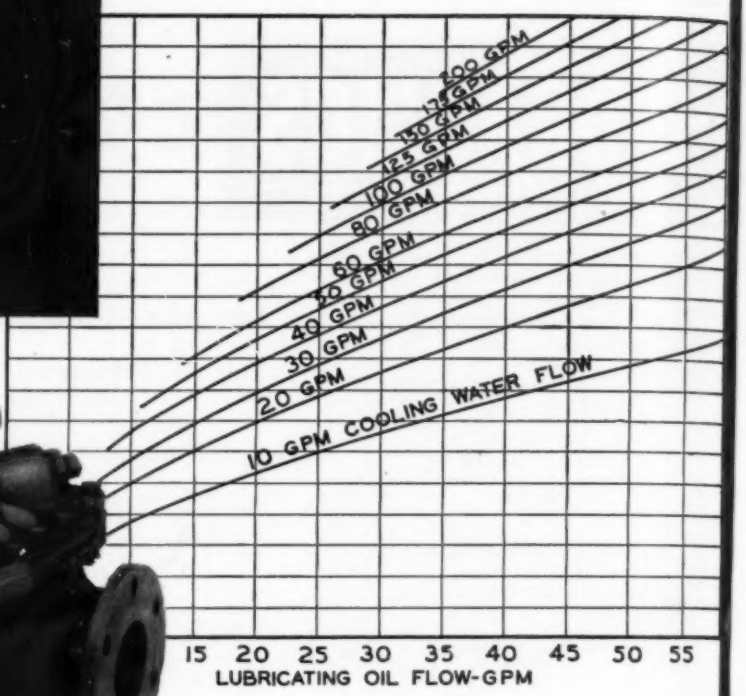
POST SCRIPTS OF INDUSTRY 39

THE MARKET PLACE 39

Applied Hydraulics is indexed regularly by Engineering Index, Inc.

All communications should be addressed to APPLIED HYDRAULICS 1240 Ontario Street, Cleveland 13, Ohio

HARRISON OIL COOLERS

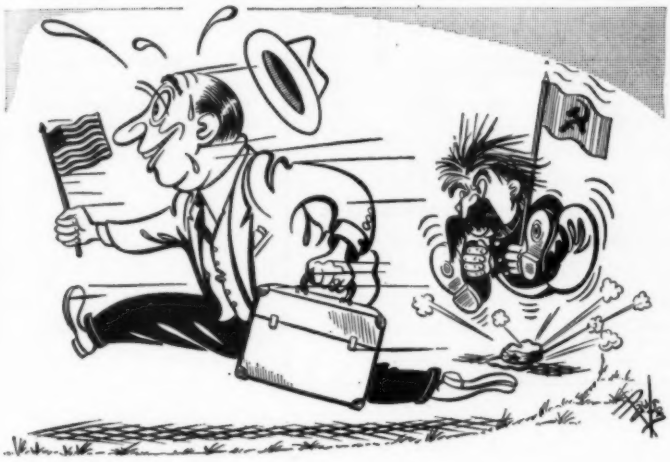


Compact · Efficient Reliable

BUILT TO DO A JOB AND DO IT WELL

HARRISON

HARRISON RADIATOR DIVISION, GENERAL MOTORS CORPORATION, LOCKPORT, N. Y.



Gold Brick...

OR THE REAL THING?

IF a cracking good salesman with a topflight product is up against a competitor with shoddy goods and a wide reputation as a widewinding liar, what does he do? Go home and lie down . . . or get out and sell circles around the bird? You guessed it right the first time.

Well, you good salesmen of America and the "American Way", we've been having too long a siesta . . . and during our complacent dreaming the Red Comrades have been peddling their tattered and damaged goods to a lot of our prospects. With word magic and a lot of sinister hocus pocus they have half-convinced a lot of folks . . . too many of them.

Have we got something good? Boy, HAVE WE! Does it work for the benefit of all? Can an ordinary fellow use it in his climb to better things? Does it give the individual the incentive to go places? What about service . . . is it guaranteed? If you've got good answers to those questions, your sales manager, Uncle Sam, needs you out on the road pouring that sales story into every open ear you can find. There may come a time when we can use restrained selling again, but NOT NOW.

Let's load ourselves up with selling ammunition come Flag Day. Let's go out with the original and only genuine brand of 100 percent American stuff. Let's lick the guy in the pink suit and the Red tie . . . and win this contest of selling ideas . . with ingenuity, eloquence, conviction and UNSHAKABLE LOYALTY.

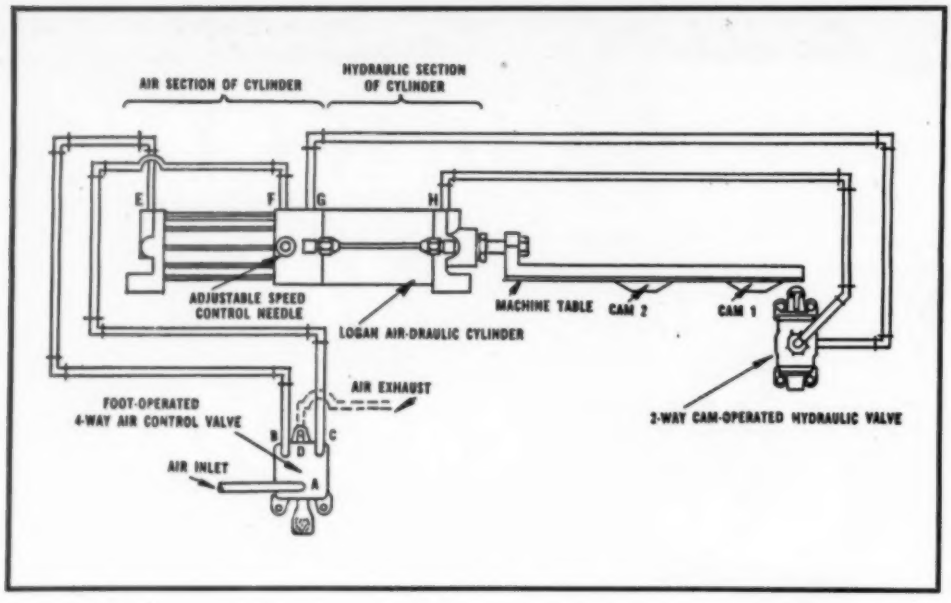


Fig. 1. One of the widely used air-powered hydraulic circuits. This is a standard unit made by a leading manufacturer.

THE *Air-Powered* HYDRAULIC CIRCUIT

The air-powered hydraulic system has the advantages of simplicity and low cost, economy of operation, positive control and range of speeds, more operating time per start and low maintenance. Several arrangements of the basic circuit are shown.

By CLARENCE JOHNSON
Consulting Engineer
Cleveland, Ohio

AN AIR-POWERED HYDRAULIC SYSTEM is an hydraulic system in which the oil pressure is produced by compressed air rather than by a motor driven oil pump. The principle is not new but its application has been limited until the past few years because industry has not been aware of its advantages. As so often the case, customer users seem to be more aware of these advantages than most designers or machine builders, since many of the applications are made by means of ingenious attachments that are now being put on all types of equipment. Several variations of the basic design of air-powered hydraulic units will be discussed to illustrate the wide range of applications of such circuits.

In the air-powered hydraulic circuit the motor, pump, reservoir, relief valve, etc., are replaced, in the elementary form, by an air cylinder pushing on an oil cylinder. The oil is by-passed around a piston through a throttling or metering valve which controls the rate of advance of the system. In a conventional hydraulic system, the pump produces oil pressure on one side of the piston and the rate of travel is controlled by throttling the exhaust. The air-powered hydraulic system has the same solid, positive and smooth action which has made hydraulics so popular as a control medium.

Where it is applicable, the air-powered hydraulic circuit has a number of advantages. It's utter simplicity actually has made some orthodox designers wary of it. Cost is low. Since it is essentially a sealed system, dirt, water and other foreign materials cannot get into the hydraulic circuit on a correctly designed ma-

ADVANTAGES OF AIR-POWERED HYRAULICS

1. **Simplicity**
2. **Low cost**
3. **Low over-all bulk**
4. **Economical of power**
5. **Energy released as required**
6. **Excellent speed control and range**
7. **No warm-up period necessary**
8. **Clean**
9. **Sealed unit construction**
10. **All advantages of conventional hydraulic system (for most applications)**
11. **Low maintenance**

chine. "O" rings have proven very successful on this type of application. Since the power requirements float on the potential energy of the plant compressed air supply, energy may be released rapidly when needed; none is consumed when the unit is idle. A wider speed range than is usual in a conventional hydraulic system is easily obtained.

In a conventional hydraulic system, the lubricating and sealing qualities of the oil must always be taken into account because of the close fitting metal to metal seals of the working parts of the oil pump. Oils for such service are fairly heavy and change their viscosity considerably as the systems warm up. It is customary to give such systems a warming up period of one-half to two hours. This time is, of course, unproductive.

In air-powered hydraulic circuits seals are usually of leather or synthetic rubber. Almost any liquid, including water, will lubricate such seals. The oil for such systems may, therefore, be selected for its control characteristics rather than for its lubricating qualities. One of these characteristics is that speeds must remain substantially constant after the unit has been in operation for some time. This characteristic can be obtained with some of the new oils developed during the war. These oils, almost as thin as kerosene, cannot be used with a pump, but they are perfectly satisfactory in air-powered circuits.

Very little heat is generated in an air-powered hydraulic system. The metering valve becomes only warm to the touch when the system is reciprocating rapidly and continuously. On the other hand, heating up of the hydraulic system is a serious problem on machines working to close accuracies, e.g., grinders, because the heat tends to warp the machine frames or bed. For this reason, some builders of precision grinders both isolate and insulate the hydraulic systems.

Air-powered hydraulic circuits are also free of the messiness often found around a conventional hydraulic system.

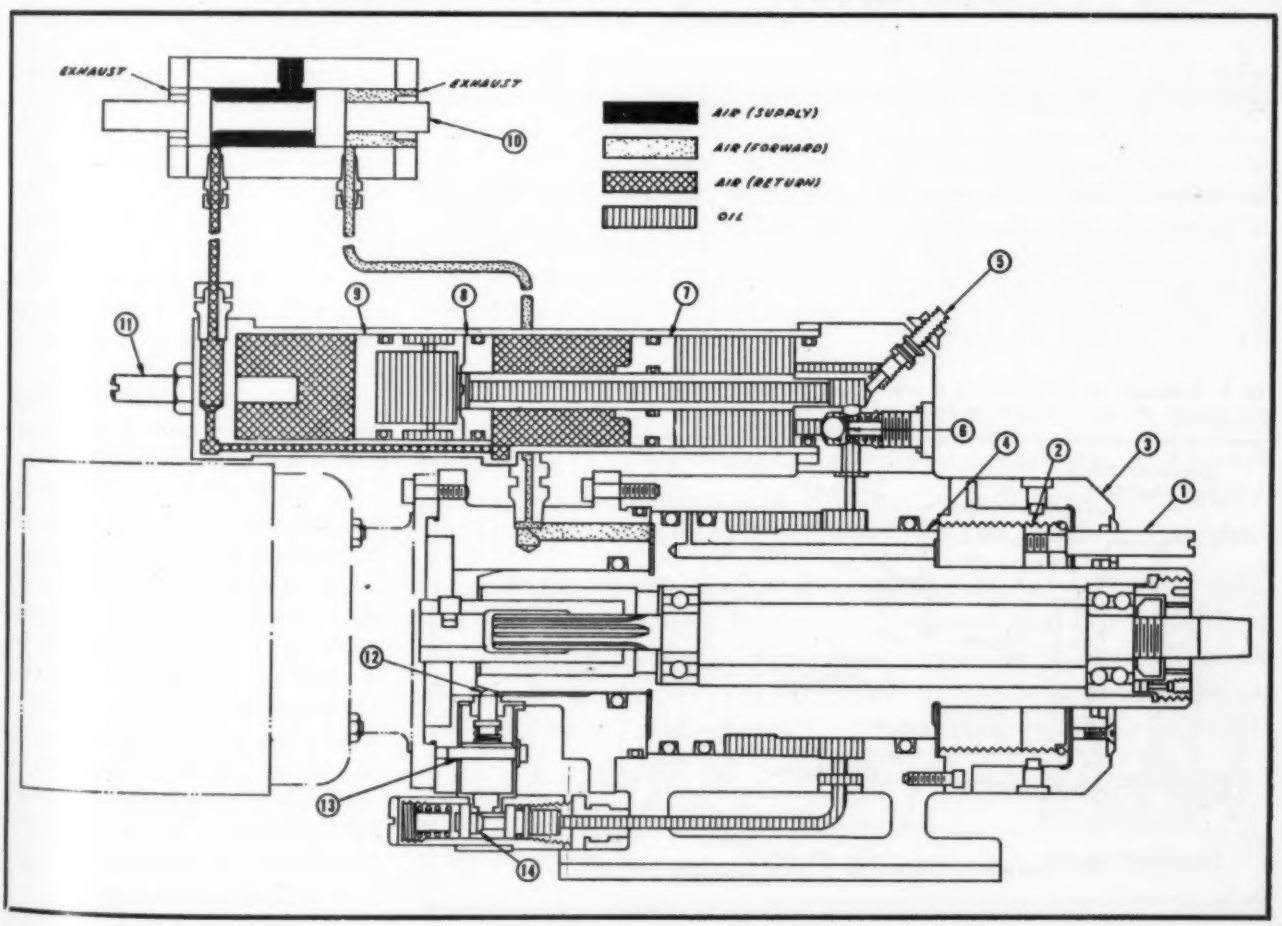
Since the operating pressure is around 100 psi (the usual plant air system pressure) the cylinder gets fairly large for heavy pressures. However, the overall bulk is generally still less than that of a conventional hydraulic system when the motor, reservoir, etc., are taken into account.

The air-powered hydraulic circuit has been successfully applied as feed control on lathes, milling machines, drill presses, etc. It is a good drive for indexing mechanisms. It is also a good "jerk-free" mechanism on valves, dampers, door and window devices and many other mechanical movements.

Figure 1 shows one of the most widely used air-powered hydraulic systems. Essentially, it consists of two cylinders in tandem, the rear operated by compressed air, the forward is the hydraulic control cylinder. If the valve is closed tightly, the mechanism cannot move. The rate of travel is controlled by the opening of the valve. Sometimes the air cylinder is larger than the oil cylinder. Check valves are sometimes used to allow the cylinder to travel fast in one direction and at a controlled rate in the other direction.

Other valves to accomplish skip-feed or remote control (master valve of the electric solenoid operated

Fig. 2. Flow diagram arranged for a drive for a single spindle drill unit.



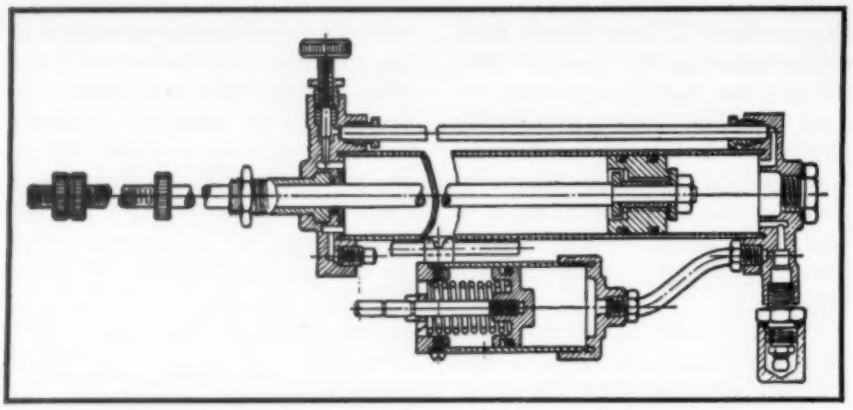


Fig 3. An "off-set" design of the basic circuit. This design permits rapid approach to the work before the hydraulic control takes over and gives accurate control of feeding traverse during the cutting operation.

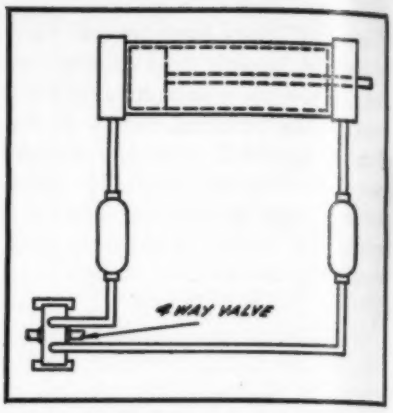


Fig. 4. Bladder-type accumulators used as separators permit any cylinder to be operated as a hydraulic cylinder.

type) are also available.

Figure 2 is a flow diagram of an air-powered hydraulic circuit which has been applied as a drive for a single spindle drill unit.

In the work stroke air valve 10 moves to the right, applying pressure to the forward air circuit and exhausting return air. Air pressure against the end of piston 4 moves the piston rapidly to the right, forcing oil through free passages to piston 9. This drives piston 9 left against rapid stop 11. The same movement of piston 4 forces oil against piston 14, moving it to the left to maintain the electrical circuit.

As oil pressure is built up, oil is forced through metering valve; piston 4 then moves to the right at controlled speed. Oil from the metering valve 5 also forces piston 7 to the left. At the end of its stroke, piston 4 strikes stop nut 2 and the oil pressure drops. As the pressure drops it allows spring pressure to move piston 14 to the right, breaking the switch contact, de-energizing the solenoid valve and causing air valve 10 to reverse.

Air valve 10 moves to the left, applying pressure on the return air and exhausting the forward air circuit. Oil piston 9 is moved right against center stop 8. This begins to return piston 4, causing check valve 6 to open. Oil flows through the valve, moving piston 7 to the right and piston 4 to the left until the latter strikes the left end of its cylinder. As piston 4 fully retracts, it strikes operating pin 12 of switch 13, closing the circuit and repeating the cycle.

"Off-Center" Arrangement

Figure 3 is basically the same as Figure 1 except that the cylinders are not on the same center line. The "pick-up" may be spaced apart on the rod to permit rapid approach to the work before the hydraulic control takes over. The rod for the hydraulic cylinder passes entirely through, assuring that the displacement is the same on both sides of the piston. The rod, also, must be of exactly the same diameter on both sides of the piston to avoid an intensifier action which could easily burst a thin-walled cylinder or blow a gasket.

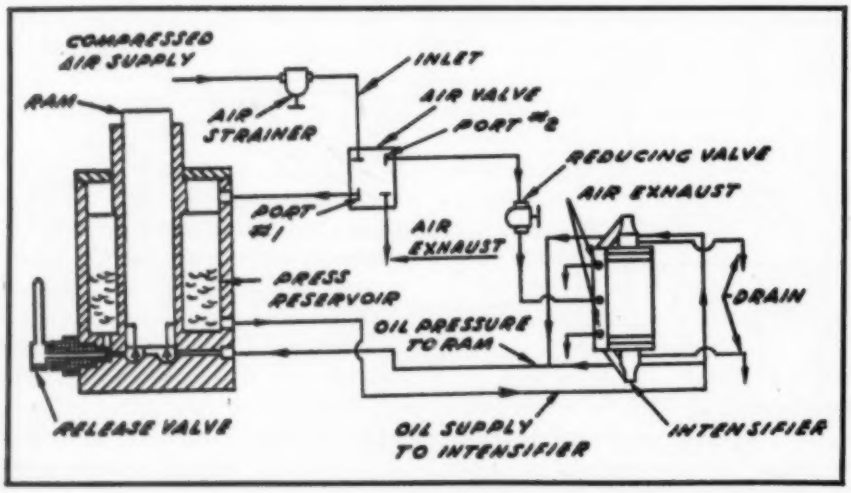
Figure 4 is a simple arrangement in which two bladder-type accumulators are used as separators. This suggested arrangement permits any cylinder to be operated as a hydraulic cylinder. Accumulators in separating chambers are connected, one to each end of the cylinder. Check and control valves in the oil line control the rate of travel. If the air does not contain moisture, air pressure can be impressed directly on top of the oil.

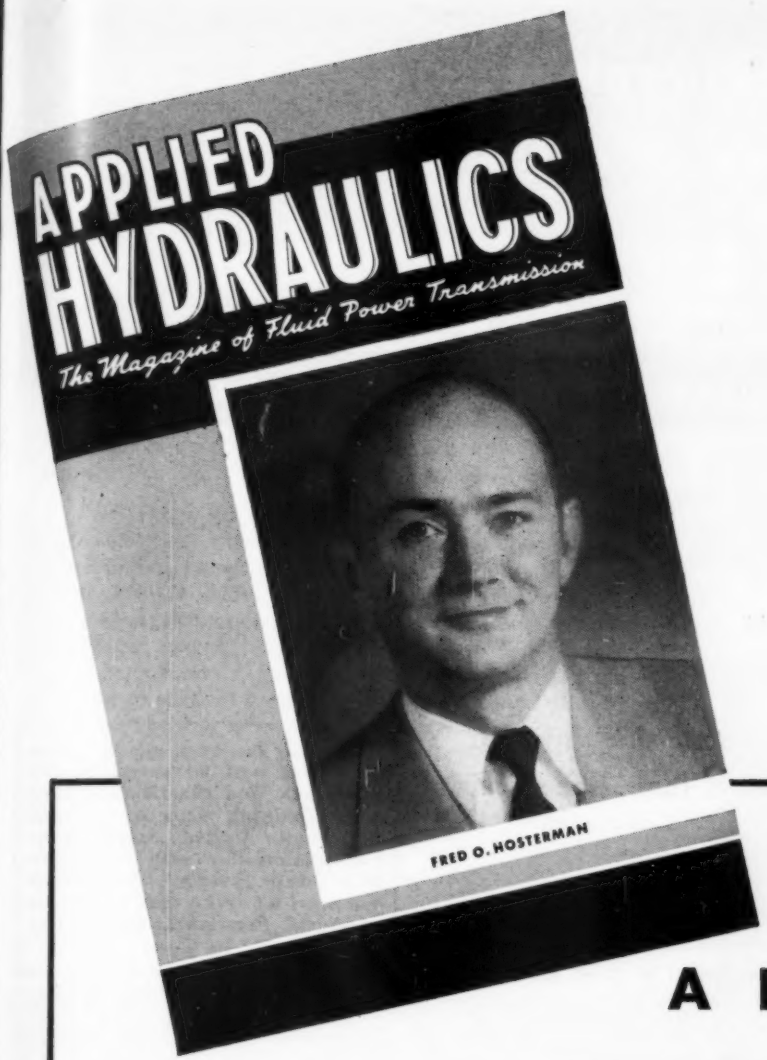
Figure 5 diagrams an arrangement of the air-powered hydraulic circuit designed for use on a small plastic molding press. A reciprocating air-driven piston operates two hydraulic plungers on opposite ends of the cylinder. Step up in oil pressure is achieved by an intensifier. A slide valve with a flat seating surface controls the reciprocating action of the air piston. Air is admitted to the proper end of the slide valve through pilot valves which are tripped in turn at each end of the cylinder.

To operate the pressman moves the three-way control valve to the "closing" position. This opens port No. 1 of the valve, admitting air above the liquid level of the press reservoir. Hydraulic pressure moves the platen at the rapid closing rate. The pressman then reverses the valve level to the "press" position, admitting air through port No. 2 into the intensifier. This actuates the air slide valve and piston, building up a pressure against the oil to provide a con-

(Continued on page 26)

Fig. 5. A design for actuation of a small, fast, molding press, using an intensifier to step up 90 psi air pressure to 6000 psi hydraulic pressure.





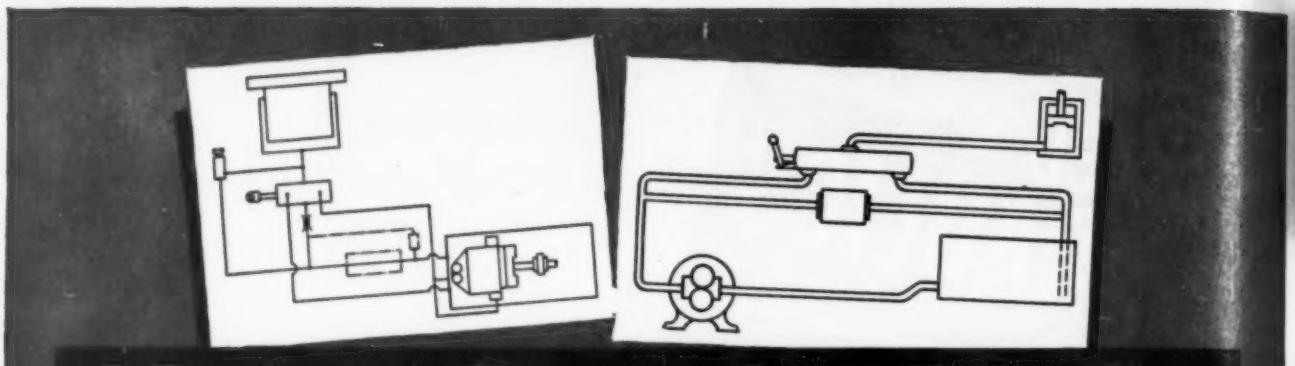
ANNOUNCES A NEW SECTION

Fred O. Hosterman, hydraulic design specialist, Lockheed Aircraft Corporation, Burbank, Calif., has accepted appointment as advisory editor on aviation hydraulic systems, components and problems to APPLIED HYDRAULICS and will edit a new Section on Aviation Hydraulics beginning with this issue. **See page 20.**

Mr. Hosterman, a Pennsylvanian, has been with Lockheed for nearly 13 years. Twelve years of experience in hydraulics and hydraulic design and application problems makes Mr. Hosterman one of the "veterans" in the field.

He is a member of SAE A-6 Committee, Aircraft Hydraulic and Pneumatic Equipment, chairman of the subcommittee on Materials of the Technical Advisory Committee on Hydraulic Systems and chairman of the subcommittee on Non-Flammable Hydraulic Fluids of the ARTC (Aircraft Research and Testing Committee).

For Mr. Hosterman's plans, turn to page 20



A Beginner's Course in Basic Hydraulics

Chapter II

LIQUID FLOW

A description of flow in liquids and the physical forces that act upon liquids to affect their behavior.

This series has been adapted from a special text prepared by the Standards and Curriculum Division, Training Bureau of Naval Personnel, United States Navy. This material is used by permission. Any further reproduction use must be authorized by Bureau of Naval Personnel, Department of the Navy.

Description of Flow

IN ORDER TO UNDERSTAND HYDRAULIC systems in action, it is necessary to become acquainted with some of the elementary characteristics of liquids in motion. Among these are volume and velocity of flow, steady and unsteady flow, streamline and turbulent flow and, even more important, the force and energy changes that occur in flow and the relations of different kinds of energy to each other in hydraulic systems.

Under normal working conditions the liquid in a hydraulic system is under pressure and completely fills the pipes of the system. This pressure is in part due to the force of gravity or weight of the liquid, and in part to externally applied forces such as might result from the action of the the pump, which in turn might have energy supplied to it by an electric motor.

All of the different factors mentioned above will be taken up step by step as we proceed.

Volume and velocity of flow. By volume of flow we mean the quantity of liquid that will pass a given point in a hydraulic system in a unit of time. Volume of flow can be stated in a number of ways, as for example, 100 cubic feet per minute, 100 gallons per minute or per hour, etc. Gallons per minute is the usual way of expressing volume of flow.

Velocity of flow means the rate or speed at which the liquid is moving forward at a particular point in the system. It, too, can be variously stated, but the usual method is in feet per second.

Volume and velocity of flow are often considered together. With other conditions unaltered—i.e., with volume of input unchanged—the velocity of flow increases as the area of cross section or size of the pipe decreases, and velocity of flow decreases as the cross section area increases. In a stream, velocity of flow will be slow at wide parts of the stream and rapid at narrow parts,

(Continued on page 16)

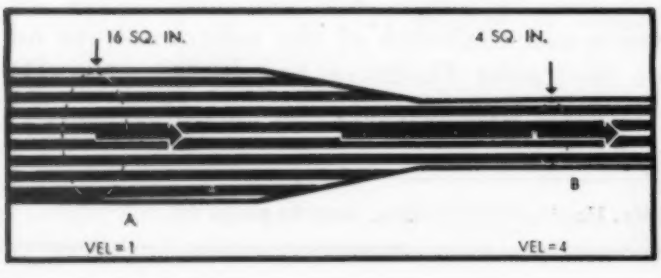


Fig. 21. The relation between volume and velocity of flow of a liquid in a pipe.

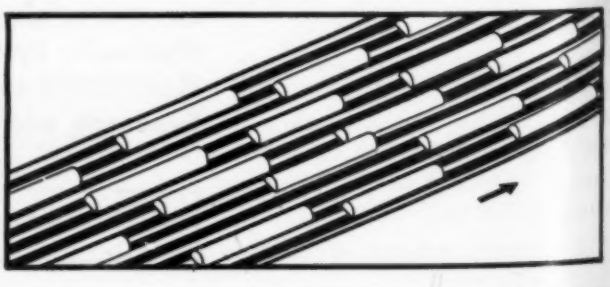


Fig. 22. A streamline flow of liquid particles acts like logs floating in an open, straight run of stream at low velocity.

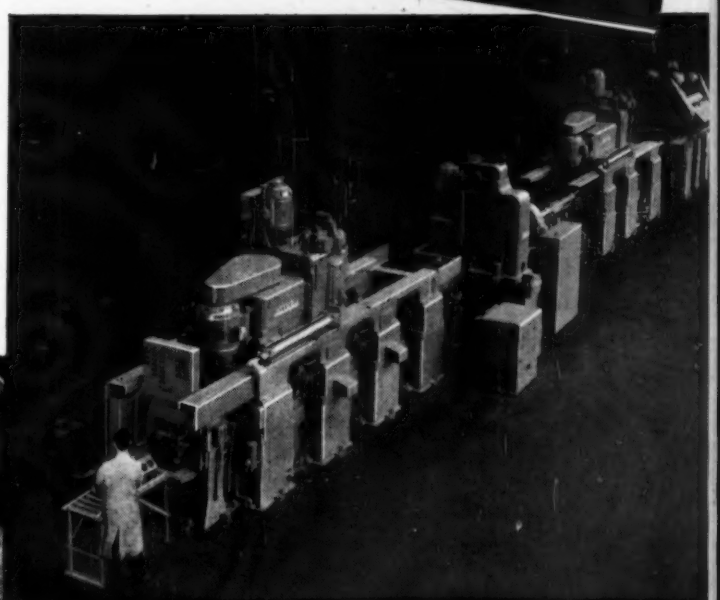
INGERSOLL PROCESS MACHINES For Reducing the MAN HOURS per piece

Another COST-CUTTING Application of VICKERS HYDRAULICS

The two Ingersoll Process Machines illustrated here are being used for completely machining automobile cylinder blocks . . . they provide the extreme precision required and at the same time reduce the cost. It is significant that Ingersoll selected Vickers Hydraulic Controls for the many operations that can best be done with hydraulics.

Progression of the blocks through the machines is accomplished automatically, the time-saving transfer mechanisms being hydraulically actuated. Hydraulic circuits of the individual units provide for correct sequential positioning, clamping, traversing, feeding and returning. Interlocks assure accurate positioning, secure clamping and removal of interfering transfer members before cutting operations begin . . . also clearance of all cutters before transfer to next station can take place. Objectionable deflection is prevented by limiting the clamping pressure.

Get in touch with the nearest Vickers Application Engineering Office for information on how Vickers Hydraulics can improve your products.



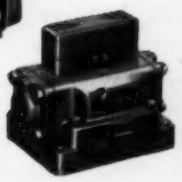
Ingersoll 9-Station Process Machine has Vickers Hydraulic Controls to help secure extreme precision in cylinder blocks at lowest cost.

Ingersoll 11-Station Process Machine receives cylinder blocks from machine at right and similarly has Vickers Hydraulic Controls.

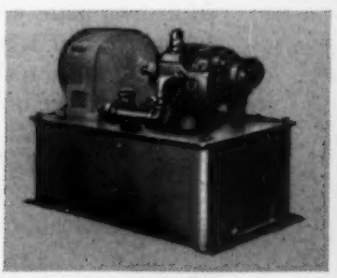
Representative **VICKERS HYDRAULIC CONTROL UNITS USED ON INGERSOLL PROCESS MACHINES**

Pressure Controls, Bulletin 45-34a

Flow Control Valve, Bulletin 45-35



4-Way Valve, Pilot Operated, Solenoid Controlled, Bulletin 48-27



Power Unit, Bulletin 46-43a

VICKERS Incorporated

DIVISION OF THE SPERRY CORPORATION

1474 OAKMAN BLVD. • DETROIT 32, MICHIGAN

Application Engineering Offices:

ATLANTA • CHICAGO • CINCINNATI • CLEVELAND • DETROIT
LOS ANGELES • NEWARK • PHILADELPHIA • PITTSBURGH
ROCHESTER • ROCKFORD • ST. LOUIS • SEATTLE • TULSA
WASHINGTON • WORCESTER

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

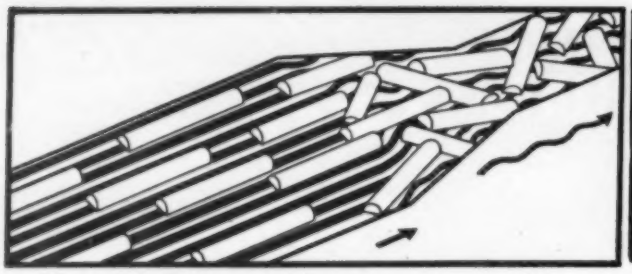


Fig. 23. A narrowing or restriction in a stream increases velocity and sets up turbulence. Particles of liquid act similarly to floating logs under such conditions.

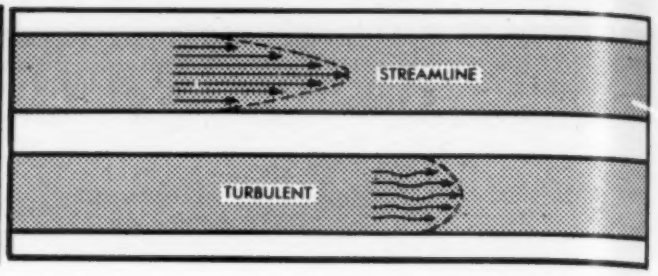


Fig. 24. The range of velocity is greater from center to edge in a streamline flow than in a turbulent flow. In the first, the average velocity is approximately half the maximum velocity; in the latter, the average velocity is about four-fifths the maximum.

(Continued from page 14)

even though the volume of water passing each part of the stream is the same. In Figure 21, if the area of cross section of the pipe is 16 sq in at point A and 4 sq in at point B, the velocity of flow at B will be four times the velocity at A.

Steady and unsteady flow. A liquid may flow at a single continuous stream, or the volume of flow may increase, decrease or fluctuate from moment to moment. Such changes in volume constitute unsteady flow. Thus, when we turn on a faucet the initial flow will be unsteady during the short time that the rate of flow of the liquid is increasing from the initial zero rate to the full rate of flow. The flow will then become steady and will be maintained if the pressure remains constant. If the pressure changes, the rate of flow once more will become unsteady until a new balance is reached.

Streamline and turbulent flow. At quite low velocities or in tubes of small diameter, flow will be streamline, meaning that a given particle of liquid will move straight forward without crossing the paths followed by other particles, and without bumping into them. As an example of streamline flow, let us consider Figure 22, where we have an open stream flowing at a slow uniform rate with logs floating on its surface. The logs can be taken to represent particles of water. So long as the stream flows along at a slow uniform rate, each log will float downstream in its own path, without crossing or bumping other logs.

If the stream narrows, however, and the volume of flow remains the same, the velocity of flow will increase. If the velocity increases sufficiently, Figure 23, the water will become turbulent. Swirls, eddies and cross-motions will be set up in it. As this happens, the logs will be thrown against each other and against the banks of the stream, and the paths followed by different logs will cross and recross.

Particles of liquid in pipes act in the same manner. The flow will be streamline if the liquid flows slowly enough, and will remain streamline at greater velocities if the diameter of the pipe is small. If the velocity of flow or size of the pipe increases sufficiently, the flow will become turbulent.

One effect of turbulent flow is shown in Figure 24, where the length of the horizontal arrows indicates the relative velocities of flow at different places in a pipe, from the center to the edge, when the flow is streamline and when it is turbulent. In both instances the rate of flow varies from the center of the pipe to the edge, but streamline flow varies more in velocity than turbulent flow. For streamline flow the average velocity is about half the maximum velocity; for turbulent flow it is about four-fifths. Velocity of flow, of course, varies both vertically and horizontally, or from the center of the pipe outwards. In both streamline and turbulent flow, the liquid lying next to the pipe will have little or no velocity.

While a sufficiently great velocity of flow will produce turbulence in any pipe, other factors than velocity contribute to turbulence. Among these are roughness of the pipe, obstructions and degree of curvature of bends and the number of bends in the pipe. In setting up or maintaining a hydraulic system, care should be taken to eliminate or minimize as many causes of turbulence as possible, since the energy consumed by turbulence is wasted. The pipe should be clean and smooth on the inside, and should contain as few bends as possible. In pipe bends the smallest degree of turbulence occurs when the pipe is bent on a radius of 2½ to 3 times the inside diameter of the pipe, as shown in Figure 25. Pipe bends must be smooth and uniform, and the inside diameter of the pipe at the bends should be the same size as all other parts of the pipe. A pipe bender should be used if possible, or the pipe should be filled with sand or a low melting point alloy when the bend is made.

While designers of hydraulic equipment do what they can to minimize turbulence, it cannot be avoided to any considerable degree. Thus in a four inch pipe at 68 F, flow becomes turbulent at velocities over about six inches per second—or over about three inches per second for a six inch pipe. These velocities are far below those commonly met in hydraulic systems, where velocities of more than five feet per second are frequent. In streamline flow losses due to friction increase directly with the velocity, while with turbulent flow these losses increase much more rapidly.

Factors Involved In Flow

Inertia. Before we can understand the behavior of liquids in motion, or of solids either for that matter, it is necessary to understand what is meant by inertia. Inertia is the term used by scientists to describe that property possessed by all forms of matter which makes the matter resist being moved if it is at rest, and likewise, resist any change in its rate of motion if it is moving.

The basic statement covering the action of inertia is: "A body at rest tends to remain at rest, and a body in motion tends to continue in mo-

tion with the same velocity and in the same direction." This is simply saying in more scientific terms what everyone has learned by experience —that one must push on an object to get it moving and offer an opposition to stop it again.

A familiar illustration in the effort a pitcher must exert to make a fast pitch and the opposition the catcher must put up to stop the ball. Similarly, considerable work must be done by the engine of an automobile to get the car started, although after it has attained a certain velocity it will roll along the road at uniform speed if just enough effort is expended to overcome friction, while brakes are necessary to stop its motion. Inertia also explains the kick or recoil of guns and the tremendous striking force of bullets and shells.

Relation between inertia and force. In order to overcome this tendency to resist any change in its state of rest or motion, some force, which is not otherwise cancelled or balanced, must act upon the object. Some unbalanced force must be applied whenever liquids are set in motion or speeded up; while conversely, forces are made available to do work elsewhere whenever liquids in motion are retarded or stopped.

In Figure 26, ignoring friction, if the force A will produce a velocity of 10 miles per hour when it is applied to a body for 5 seconds, it will produce a velocity of 20 miles per hour when it is applied for 10 seconds. The same result of 20 miles per hour would be attained if a force B, equal to twice A, were applied to the body for 5 seconds. Again ignoring friction, the body would be returned to rest from a velocity of 20 miles per hour if force C, equal to A but acting in the opposite direction, were applied to it for 10 seconds, or if a force D, equal to twice C, were applied to it for 5 seconds.

There is a direct relationship between the magnitude of the force exerted and the inertia against which it acts. This force is dependent on two factors: the mass of the subject (which is proportional to its weight); and rate at which the velocity of the object is changed. While the mathematical relationship between inertia and force is outside the scope of this course, it is included for those who may be interested. The rule is that the force in pounds required to overcome inertia is equal to the weight of the object, multiplied by the change in velocity measured in feet per second, and divided by 32.2 times the time in seconds required to accomplish the change. Thus the rate of change in velocity of an object is proportional to the force applied. The number 32.2 appears because it is conversion factor between weight and mass.

Factors governing hydraulic action. We remember that liquids are always acted upon by the force of gravity, i.e., by their own weight. Also that liquids are acted upon by atmospheric pressure, if the system is not completely enclosed. The action of specific applied forces has been explained and we have learned that whenever there is movement there is always some friction. We have just introduced a new factor—inertia—which completes the list of forces controlling the action of liquids at rest and in motion.

There are just five physical factors which can act upon a liquid to

(Continued on page 19)

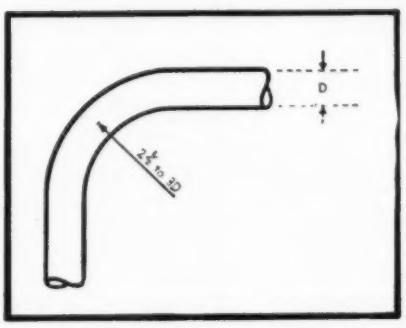


Fig. 25. A good bend design for minimum turbulence of flow is a radius of 2½ to 3 IDs of the pipe.

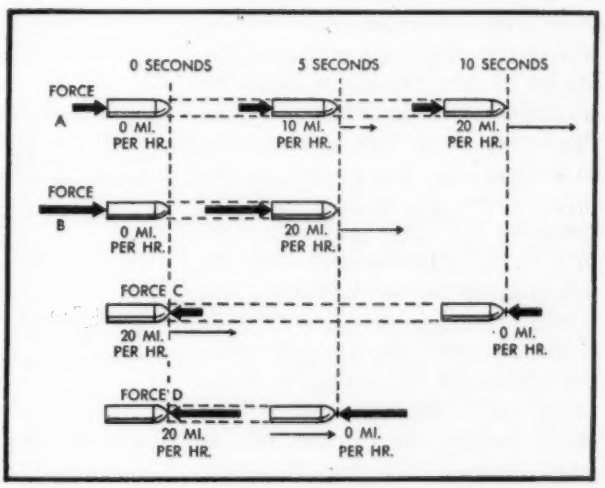


Fig. 26. The relationship of force and inertia, ignoring friction, is shown schematically. Forces A and B produce velocities; forces C and D return the body to rest.

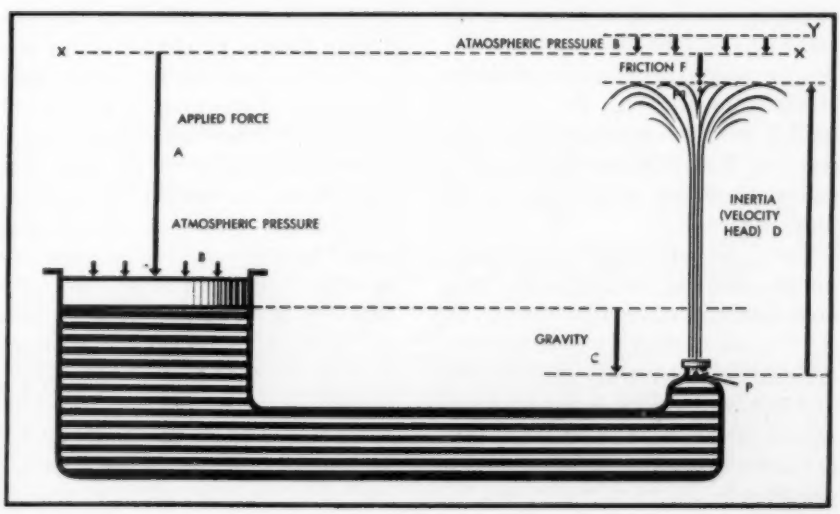


Fig. 27. The five physical factors which act upon a liquid are shown in terms of head. The particle of liquid P is being acted upon by an applied force A, atmospheric pressure B, gravity head C, inertia or velocity head P1, while head equivalent to F represents the friction loss as P passes through the system.

EGGS, OVER LIGHTLY

THE PETERSIME INCUBATOR CO., Gettysburg, Ohio, a major manufacturer and supplier of equipment to the poultry industry, has pioneered a fully automatic, hydraulically actuated device for rotating the egg drums in their line of standard incubators. In addition to the great saving in labor, the slow, smooth operation of the actuating cylinder in turning the drum arm is positive protection for the delicate membranes of the incubating eggs, eliminating the losses, which sometimes are considerable, from fast, rough manual drum turning.

The Petersime 2600-egg incubator (Figure 1) is the first to be equipped with the automatic hydraulic system. Eggs must be turned at regular intervals of 2 to 6 hours throughout their period of incubation. A turning arm on the side of the incubator (see Figure 2) formerly had to be swung through an arc of approximately 110 degrees by hand. With an unbalance of from 75 to 200 pounds on the lever, there was a temptation to heave on the lever and swing the drum rapidly, particularly when the operator was pressed for time or was tired.

The hydraulically operated cylinder eliminated the drudgery of rotating the drums by hand. A time clock operates the cylinder exactly when desired, swinging the drum smoothly and slowly—20 seconds to swing from one end of the arc to the other. As shown in Figure 2, the double acting, actuating cylinder is clevis mounted, with its piston attached to the operating arm. The operator is setting the time clock to demonstrate the functioning of the unit.

The hydraulic system consists of pump and tank, electric motor, solenoid operated valve, relief valve and the 2 in, 11 in stroke actuating cylinder. Flexible hose connections to the cylinder ports allow the cylinder to move through a small arc as its piston extends or retracts at each operating cycle. All elements except the cylinder and time clock are housed in a convenient cabinet which may be placed on the floor alongside the incubator or mounted on the side wall as shown. As the pump operates only during the 20 second cylinder cycle cost of operation is very small.

Fig. 1. The standard 2600-egg Petersime incubator, the first to be equipped with an automatic, hydraulically actuated drum turning device.

Fig. 2. The operator sets his time clock, then forgets he ever had to turn the heavily unbalanced lever by hand.

The Petersime company, as an old established leader in its field, was just as much interested in an automatic drum turning power unit that would be applicable to the thousands of units already in service as to the new units. A leading manufacturer of hydraulic components designed the system so that it is equally adaptable to manually operated incubators. The installation of the hydraulic system can be done by any mechanically minded poultry man. The entire system is outside the incubator; the power unit can be clamped or set in any position convenient to operate the cylinder which requires only a single fixed mounting.

The hydraulic system has ample power to operate incubators up to 42,000-egg capacity.

BASIC HYDRAULICS

(Continued from page 17)

affect its behavior. All of the physical actions of liquids in all possible systems are determined by the relationships of these five factors to each other. Summarizing, these factors are:

Gravity, which acts at all times upon all bodies, regardless of all other forces;

Atmospheric pressure, which acts whenever any part of a system is exposed to the open air;

Specific applied forces, which may or may not be present, but which are entirely independent of the presence or absence of motion;

Inertia, which comes into play whenever there is a change from rest to motion or vice versa, or whenever there is a change in direction or in rate of motion; and

Friction, which is always present whenever there is motion.

Figure 27 diagrams a possible relationship of these factors with respect to a particle of liquid P in a system. The different forces are shown in terms of head, i.e., vertical columns of liquid required to produce the forces. As illustrated, a particle of water P is being acted upon by an applied force equivalent to a head of A, by atmospheric pressure equivalent to a head of B, and by a gravity head C, produced by the weight of the liquid standing over it. The particle possesses sufficient inertia or velocity head to rise to the level P_1, since head equivalent to F was lost in friction as P passed through the system. Since atmospheric pressure B acts downward on the system on both sides, what was gained on one side was lost on the other.

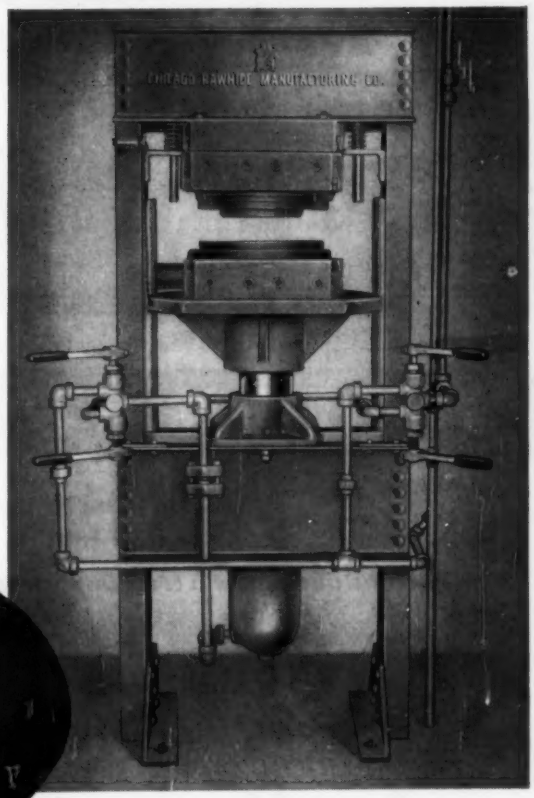
If all the pressure acting on P to force it through the nozzle could be recovered in the form of elevation head, it would rise to the level Y; or, if account be taken of the balance in atmospheric pressure, in a frictionless system it would rise to the level X, or precisely as high as the sum of gravity head and the head equivalent to the applied force.

Next month Chapter II will continue with kinetic energy, pressure and head relations in flowing liquids and the relation of static and dynamic factors. Preserve each section for future reference.

IN REPLACING HYDRAULIC PACKINGS

SAVE TIME and MONEY

specify sirvis



Replacing the "U" ram packing on a hydraulic press is an expensive procedure. Usually it involves dismantling the press, and the cost of installation is much greater than the cost of the packing itself. So, it's sound practice to use the best packing available. Actual tests prove that Sirvis "U" type packings deliver maximum service. On the hydraulic press illustrated, a Sirvis leather packing functions as the pressure sealing unit. Despite the extreme pressures and the action of hydraulic fluid in this application, the Sirvis packing requires less replacement than any other type. Sirvis will solve your packing problems with similar economy and service. The next time you install or replace hydraulic packings, specify Sirvis.

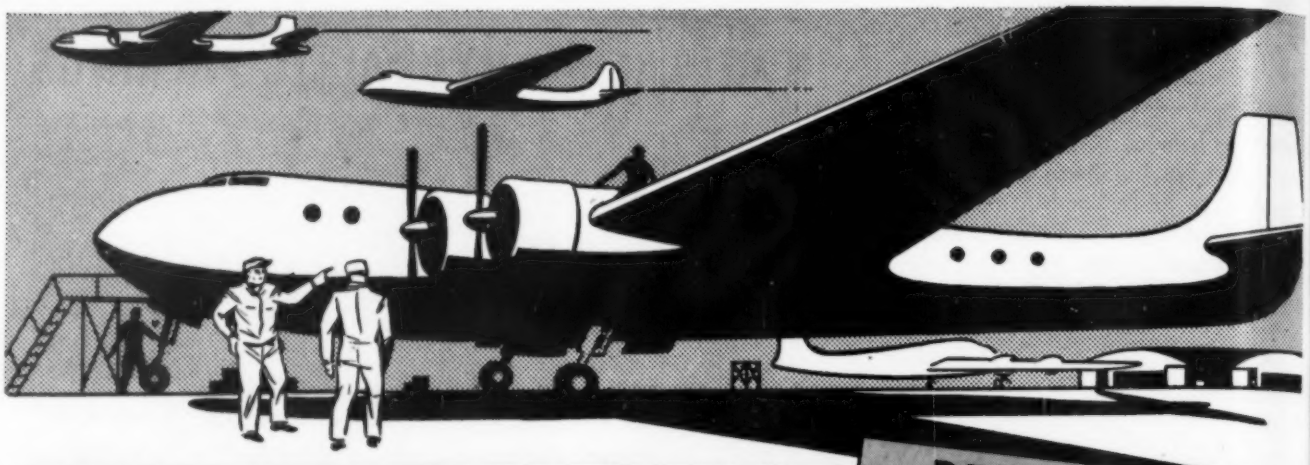
• ***SIRVIS PACKINGS** are engineered from top grade steerhide, specially tanned and treated. They are scientifically designed for all types of mechanical applications.*

MECHANICAL LEATHER PRODUCTS

sirvis

OTHER C/R PRODUCTS
PERFECT Oil Seals
SIRVENE Synthetic Rubber

CHICAGO RAWHIDE MANUFACTURING COMPANY
1301 Elston Ave. Chicago 22, Illinois
New York · Philadelphia · Detroit · San Francisco · Cleveland · Boston
Pittsburgh · Los Angeles · Cincinnati · Minneapolis · Syracuse · Peoria



AVIATION HYDRAULICS

DESIGN
OPERATION
MAINTENANCE

FRED O. HOSTERMAN
Advisory Editor

(First Installment of a New Department, see page 13)

AIRCRAFT — a challenge to HYDRAULICS

HYDRAULIC POWER WAS FIRST used in aircraft almost twenty years ago. These first systems could hardly be classified as a challenge to the medium of hydraulic power or to the ingenuity of the engineers who designed them. Often the systems consisted of nothing more than a hand-operated pump, a few appropriate valves, the actuating cylinders and the connecting piping. Nevertheless, these early systems performed their functions well and established the hydraulic system as one of the best and most reliable means for aircraft power transmission.

During the ensuing years, the hydraulic systems grew up with the aircraft. Present day airplane designs, both commercial and military, utilize hydraulic power for many purposes including the operation of landing gears, wing flaps, bomb bay doors, dive brakes, wheel brakes, nose wheel steering and surface control boosters. Auxiliary hydraulic equipment is used for such mechanisms as automatic pilots, escape devices for crew members, synchronizing remote position control, cargo ramps and hand pumps for emergency and for charging the accumulators on the ground.

The systems which transmit the power to such devices are necessarily much more complex than the earlier designs. It is noteworthy, however, that the reputation for reliability of the hydraulic system and equipment has been steadfastly maintained. To this extent, the hydraulic system has met the challenge of the aircraft designer.

But the battle is not yet won. With the improvements in aircraft performance and adaptability has come corresponding demands for operation for a wide variety of purposes and under an extreme range of climatic conditions. The increase in aircraft performance alone has brought about a demand for increased hydraulic power in smaller packages and for less total weight. These requirements have dictated the employment of ever increasing hydraulic pressures and for stressing the materials to the ultimate practical, safe limit.

The changing environmental conditions have presented an even more imposing array of problems. Present day aircraft are required to operate from airfields which may be located in the scorching desert heat or in frigid Arctic cold. They must fly for many hours in the rarified atmosphere of 50,000 feet altitude where the ambient air temperatures may be as low as —100 F. From this extreme, the new supersonic jet aircraft may also be subjected to low altitude temperatures in excess of 300 F, resulting from the adiabatic rise as the plane literally compresses the air through which it flies.

Hydraulic systems and components in new aircraft must meet the challenge imposed by these severe operating conditions. The challenge must be met without undue sacrifice of the excellent record for reliability already established. It is to the attainment of this goal that the Aviation Section of APPLIED HYDRAULICS is dedicated.

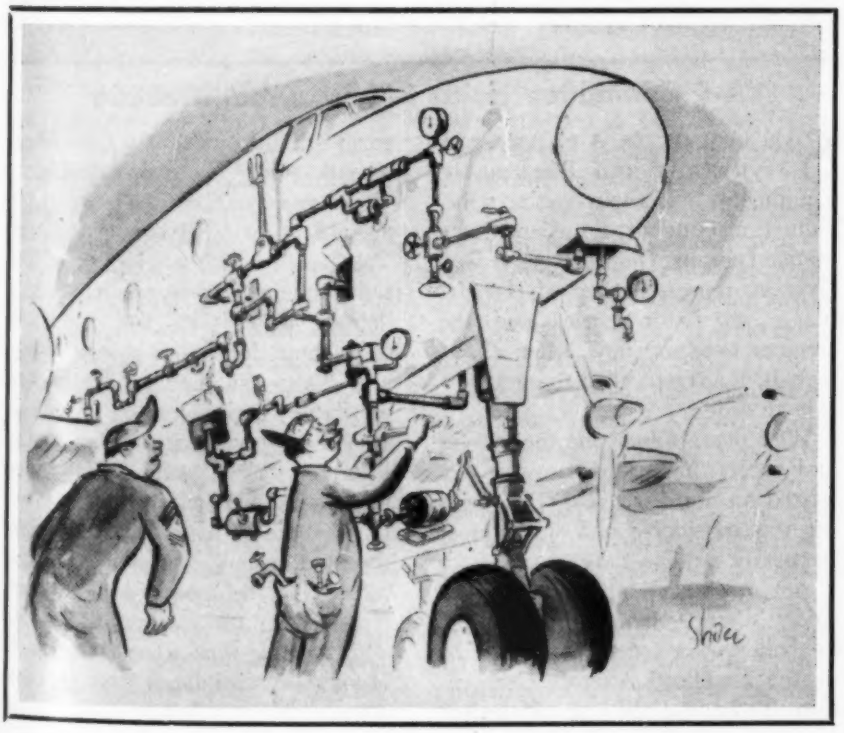
To some extent, the severe requirements imposed upon the hydraulic systems in aircraft are peculiar to the airplane alone. Nevertheless, the aircraft hydraulic engineers and maintenance men expect to learn much from the developments and experience of those working in other fields. On the other hand, the materials and techniques employed in or or developed for aircraft will prove useful to those in the industrial field. In many cases the same manufacturers are suppliers to both the aircraft and the industrial fields. The carryover of design and operational know-how from one field to the other is large in some cases. While the more rigid specifications in the aircraft field have accelerated the development of many components faster than comparable components used for general industrial applications, the net gain in technical advances made by both fields has been mutually advantageous.

Thus, while this Section will be devoted primarily to those problems of current interest or importance to aircraft, it is reasonable to assume that the problems posed and the solutions offered will prove interesting as well as useful to all who are concerned with the development and increased range of applications of hydraulic power systems.

Pneumatics too, will come in for its share of attention. Several current aircraft designs employ pneumatic systems to operate many of the auxiliary services. Both high and low pressure air systems offer many interesting possibilities for widespread aircraft use. The high pressure system appears to be particularly well adapted to services requiring infrequent operation and where high speed is desired. The low pressure system seems to offer a continuous duty power source in aircraft where the air can be obtained from the main engine compressor or from an auxiliary turbine engine used exclusively for accessory power. Usage in guided missiles* appears to be a particularly attractive field for the employment of pneumatic systems.

One of the arguments advanced in favor of the pneumatic system is that the fluid is non-flammable. It is true that both commercial and military aircraft experience with hydraulic systems has proved the need for a non-flammable fluid. This need has led to a very extensive development program designed to produce such a fluid capable of operating throughout the wide range of conditions encountered in aircraft. While no completely satisfactory fluids have been produced to date,** the results are encouraging and the developments will be reported from time to time in this Section.

** The role of hydraulic power in guided missiles is also an important one. See "Hydraulics and the Guided Missile" by E. H. Buller and Lt. B. H. Ford, APPLIED HYDRAULICS, October 1948, and reprinted in "Technical Data Digest" issue of 15 April 1949 (Central Air Documents Office, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio).*



Exchange of Information

One of the outstanding reasons for the rapid growth and steady improvement of aircraft hydraulic systems has been the free exchange of information among the engineers, manufacturers and maintenance personnel responsible for the design, production and operation of those systems. The military services and the nation's airlines have also entered into this exchange, contributing the necessary operational experience essential for continued advancement.

It will be the aim of this Section to provide an additional medium for such an exchange of ideas, developments and experiences. A number of men whose achievements in the hydraulics field have given them national recognition have already expressed their willingness to contribute on their specialties.

Among the subjects scheduled for early issues will be some of the following:

- The Problems of Hydraulic Systems in Large Aircraft
- Designing for Minimum Surge in Hydraulic Systems
- Improved Tube Fittings for High Pressure Hydraulic Systems
- Laboratory Duplication of Hydraulic Pressure Surges
- 61ST Tubing for Aircraft Hydraulic Systems
- Pneumatic Systems for Guided Missiles
- Noise Suppression in Aircraft Hydraulic Systems
- Advantages of a Closed Hydraulic System
- The Importance of Friction in Hydraulic Booster Systems
- The Case for the Open Center System

This is only a partial list of subjects to be covered in this Section.

*** "Non-Flammable Hydraulic Fluids—A Reality?" APPLIED HYDRAULICS, May 1949.*

Many others will be added as the need arises or as new developments add themselves by their own importance. Our readers are invited to make their own comments or suggestions. We pledge our very best efforts to make this Section a practical focal point for all those interested in the advancement of aircraft hydraulics, a forum for swapping ideas and assisting each other in the solution of our respective problems. Working together we can make this Section a means of extending the effort toward meeting the challenge of modern and future aircraft, so that the hydraulic system may continue to be the most dependable means of aircraft power transmission.

SAE Aeronautical Standards Program

By J. D. Redding, Manager Aeronautical Dept. SAE

IN addition to standards for hydraulic equipment standards and fluid specifications, the SAE's aeronautical standards program encompasses the broad fields of aircraft engines, propellers, instruments, utility parts, materials, drafting practices and helicopters.

Under the aegis of the SAE Aeronautics Committee, chairmanned by Arthur Nutt since its inception in 1941, the SAE program has successfully met the problem of establishing and keeping up-to-date standards in this fast moving field. Wartime and postwar standards, developed by engineers who serve on SAE committees as individuals rather than as company representatives, have helped both industry and the military services by establishing agreement between user and producer. Result: duplication has been eliminated, costs cut, interchangeability fostered and maintenance facilitated.

The 560 SAE Aeronautical Material Specifications being extensively used by engine, propeller, accessory and airframe manufacturers typify the utility of SAE aeronautical standards. These AMS cover the gamut of materials used in the field —ferrous and nonferrous metals, castings, plastics, special packaging and preservative materials, high-density, heat-resistant alloys for jet engines—as well as procedure for plating and treating these materials.

Equally as important as these AMS are the SAE Aeronautical Standards. These standards are aimed at promoting dimensional interchangeability. They cover such items as spark plugs, accessory pads, splines and propeller shaft ends, wheels, axles, internal combustion heaters and generators. In this area SAE has developed performance specifications, which serve as the basis for acceptance by the Civil Aeronautics Administration of many accessories used in civil aircraft. SAE aircraft instrument standards are one such example.

Allied with its parts standard program is a new project recently undertaken by SAE—development of standards for aircraft engines and propeller utility parts. Taken on at the request of the Aircraft Industries Association, this job stems from an industry-military agreement to promote the increased use of utility parts such as bolts, nuts, washers and gaskets on aircraft engines and propellers.

Another SAE Aeronautics Committee achievement which integrated the design-production-maintenance relationshp between producer and user of aircraft equipment is the SAE Aeronautical Drafting Manual. This comprehensive correlation of current drafting practices is now used by engine, accessory, equipment and propeller manufacturers as well as airline operators. Several colleges have adopted it as a text book in aeronautical drafting.

The procedure by which these as well as all other SAE standards and specifications are developed is as follows:

(1) Assignments originate from these sources, (a) within committee by committee members, (b) companies, (c) government agencies and military services, and (d) the Aircraft Industries Association.

(2) Existing committees are assigned these projects or new ones are created, consisting of engineering specialists from a cross-section of the companies and government agencies interested. These men serve as individuals rather than as representatives of their companies.

(3) Proposals are circulated among airplane manufacturers, accessory and equipment makers, airline operators and other interested organizations. Consideration is given to suggestions made on the proposal.

(4) Proposals are then submitted through parent administrative committees to the SAE Aeronautics Committee and finally to the SAE Technical Board. Approval must be granted by these groups before the proposal can be issued as an SAE standard, specification, recommended practice or information report.

A-6 Committee Holds Semi-Annual Meeting

SAE Committee A-6, Aircraft Hydraulic and Pneumatic Equipment, held their regular semi-annual meeting at the Van Cleve Hotel, Dayton, Ohio, on April 6-8. Over 90 representatives of the airplane, supply industries and the services were on hand when chairman B. R. Teree called the first session to order.

With over 40 items on the agenda and many important projects reported on and discussed, the meeting was considered one of the most important held to date.

As previously, a group of West Coast aircraft hydraulic engineers held an earlier meeting (March 24 at the Lockheed Aircraft Corporation, Burbank, Calif.) at which time various items on the A-6 Committee agenda were discussed. Decisions were reached on the following agenda points: Hydraulic Shuttle Valves, on which a number of detailed changes were recommended; definite instructions for inspection of backup rings were agreed upon; and changes in the specifications of allowable clearances on packings (AN-P-74) were drawn up in the interest of clarity and conformance to long established successful practice in the industry. Other points reported on and discussed were also referred to the general A-6 Committee meeting for further discussion. This meeting was attended by Jack Hudson, Consolidated Vultee; Dick Bumb, North American; John

The North American B-45 light bomber incorporates a long list of hydraulic actuating and control components in its design.

Bloom and Harry Cornish, El Segundo; Frank Murphy, Santa Monica plants of Douglas; Ward Parker, Northrup, and F. O. Hosterman, Lockheed.

Among the important accomplishments at the A-6 meeting was a rather extensive revision to specification AN-V-3, Hydraulic Shuttle Valves. The intent of the detail revisions was toward a relaxation on many of the specific requirements, so that valves could be designed which would be more universally adaptable. It is the ultimate intent that these valves be made suitable for a life of 20,000 cycles, although for the present the specification will call for only 2,000 cycles.

General agreement was reached on the revision to specification AN-V-4, Hydraulic Directional Control Valves. This specification was originally written to cover only the specific AN Standard valves currently in use, but in the revised form will cover directional control valves of all types, size and pressure ratings. Detail requirements for specific designs are now to be shown on the applicable valve drawings. General requirements for electrically actuated valves were also discussed and included in the revised specification.

Among the other specifications brought up for revision were AN-C-66, Hydraulic Actuating Cylinders; AN-J-10, Hydraulic Swivel Joints; AN-P-74, Packing Installation and Gland Design; AN-P-86, Pneumatic Systems; and AN-V-9, Hydraulic Controllable Check Valves. A new specification for Hydraulic Pressure Switches was reviewed and discussed at some length, but no final action could be taken pending further study of the applications for such devices.

Extensive discussions were held on the operation of hydraulic systems at extreme temperatures, a serious problem in current and future aircraft. E. M. Polk of Air Materiel Command reported on test experience with various aircraft at —65 F, both in the test hangar at Eglin Field, Florida, and at Ladd Field, Alaska. Both Mr. Polk and L. M. Chattler of the Bureau of Aeronautics, as well as various industry representatives reported on studies of operating problems at high temperatures (up to 400 F) which are expected to be encountered in future supersonic aircraft.

F. O. Hosterman, member of the A-6 Committee and chairman of the ARTC subcommittee on Non-Flammable Hydraulic Fluids, presented the preliminary draft of a specification for a final type fluid.

For the first time, Committees A-1, Pumps, and A-3, Fittings and Hose Assemblies, held concurrent meetings for the purpose of coordinating more closely with the A-6 Committee. These Committee meetings were held on April 4 and 5. Chairman J. M. Kidd of the A-1 Committee and Chairman L. J. Henderson of the A-3 Committee submitted reports of the important action taken by their respective groups. This method of holding concurrent meetings was considered to be highly successful and is expected to be continued in the future.

Detailed discussions of the A-1 and A-3 Committees are reported elsewhere in this Section.

Members of the A-6 Committee present included Chairman B. R. Teree of the New York Air Brake Company; Ben N. Ashton of Electrol, Inc.; J. W. Kelly of Adel Precision Products Corp.; J. Milton Kidd of Glenn L. Martin Co.; R. C. Bumb of North American Aviation; J. P. Kovacs of Purolator Products Corp.; F. A. Lewis of Linear, Inc.; Frank W. Murphy of Douglas Aircraft Co., Inc.; Fred O. Hosterman of Lockheed Aircraft Corp.; Harry Kupiec of Air Associates, Inc.; F. H. Pollard of Republic Aviation Corp.; and Walter V. Scholz of United Air Lines, Inc. Three members: D. E. Leach of Chance Vought Aircraft; J. W. Overbeke of Parker Appliance Co.; and David Wark of American Airlines, Inc., were unable to be present.

Personnel from the Air Materiel Command and the Bureau of Aeronautics, Navy Department, included E. M. Polk and L. M. Chattler, respectively. J. D. Redding, manager, Aeronautical Department, SAE, acted as secretary.

The next meeting of the A-6 Committee was announced by Chairman Teree for November 2 to 4, 1949, at the Mayflower Hotel, Washington, D. C.

SAVE COOLING WATER
Get Many Other Benefits and Cost Savings

• Niagara Aero Heat Exchangers provide faster and more accurate cooling to specified temperatures for liquids in many industrial processes. They help lower production costs.

Cooling by the evaporative principle, they transfer heat to air, which is easily disposed of, and consume less than 5% of water used in conventional cooling methods. A Niagara Aero Heat Exchanger replaces both shell-and-tube cooler and cooling tower, and saves piping and pumping. Its savings quickly return its cost.

It helps improve the quality of production by removing heat at the rate of in-put, and by greater accuracy of control. For example, as applied to heat-treat quenching or to a chemical process cooling, provision for heating as well as cooling saves the time and prevents the product losses of a "warm-up" period.

Successful applications also include control of temperatures for jacket coolants for engines, hydraulic equipment, transformers and electronic sets and special industrial equipment.

Write for Bulletin No. 96

NIAGARA BLOWER COMPANY
Over 35 Years of Service in Industrial Air Engineering
Dept. AH, 405 Lexington Ave.,
New York 17, N. Y.
District Engineers in Principal Cities

INDUSTRIAL COOLING HEATING • DRYING
NIAGARA
HUMIDIFYING • AIR ENGINEERING EQUIPMENT

A-1 Aircraft Pump Committee

SAE Committee A-1, Aircraft Pumps, under the chairmanship of J. Milton Kidd, hydraulic engineer, Glenn L. Martin Co., met at the Van Cleve Hotel, Dayton, Ohio, April fourth. The meeting was arranged immediately preceding the A-6 Committee meeting so that many interested officials and technicians could conveniently attend both meetings.

Among the most important items discussed by this Committee was the subject of pressure peaks measured at the pump outlet. This subject was brought up in order to determine whether a limitation on such peaks should be incorporated into the variable delivery pump specification, soon to be released, as well as into the specification for fixed displacement pumps, AN-P-11. It was pointed out that the peak pressures increase considerably as the pump inlet pressure decreases and that all of the pumps currently being manufactured have peaks higher than the values considered for the specification requirements. This fact, coupled with the difficulty in obtaining accurate measurements of these pressures, led to the decision to set no fixed requirements at this time. The Committee will continue to study this subject for future consideration.

Somewhat related to the subject of peak pressures was the problem of the necessary changes to the hydraulic system and to the pump performance requirements to make possible satisfactory operation at altitudes of 50,000 feet, as well as at extreme low temperatures of —65 F. Both of these conditions cause a decrease in the pump inlet pressure unless special provisions are made to maintain the inlet pressure at a satisfactory level. The Air Materiel Command is currently sponsoring extensive studies of this problem and the many possible solutions. The Committee postponed positive action on changes to the pump specifications until further data can be obtained from these studies.

As reported elsewhere in this Section, Chairman Kidd summarized this discussion at the subsequent A-6 Committee meeting.

Action was initiated to prepare suitable specifications for electric motor driven hydraulic pumps as well as for hydraulic motors.

A-3 Committee Holds Meeting

SAE Committee A-3, like the A-1 Committee, met at Dayton for two days immediately preceding the A-6 Committee meeting so that as many as possible interested technicians in the airplane and supply fields could attend sessions of both meetings. Under the Chairmanship of L. J. Henderson, sales manager, Aeroquip Corporation, a number of problems were studied.

Probably the most important item to the aircraft hydraulic system discussed by this Committee was that of the new AND 10050 boss gaskets and fittings. The new series is built around a 90-durometer "O" ring, smaller in cross section than the equivalent AN 6227 sizes, which is used in place of the rectangular section AN 902 gasket. For a straight union, the "O" ring is used alone. In a universal fitting, the "O" ring is supplemented with a leather backup ring, which is partially housed in a counterbored recess in the check nut. The leather serves, in part, to compensate for the increased boss volume encountered with the universal fitting, as well as to prevent extrusion of the rubber into the threaded section.

This series, which has been under development for nearly two years, was given final approval by the Committee.

Also approved was a new series of fittings incorporating AND 10050 bosses, designed to replace AN 925 through AN 928. These fittings incorporate heavier sections and wider boss faces, thus providing increased strength and improved sealing characteristics. The new fittings will be assigned new part numbers in order to provide positive identification.

Considerable discussion centered around flexible hose specifications AN-H-24 and AN-H-28 and the related drawings of end fittings and hose assemblies. The decisions reached by the Committee will be reflected in early revisions to these documents.

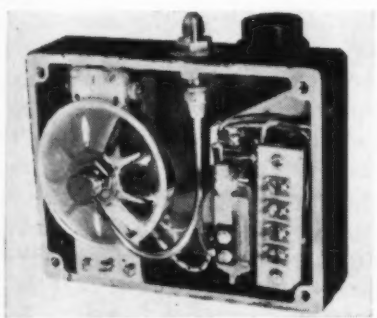
Chairman Henderson made a general report on his Committee's actions to the A-6 Committee.

New PRODUCTS

For additional information on any of these products, mark the end key numbers on the card bound in this issue and mail the card.

Nil-Pressure Actuated Switch

A new nil-pressure actuated switch for use as a safety or as a positive control of electro-mechanical devices by fluid pressure has been perfected by the Meletron Corporation. The new unit, believed to be the first of its type, is used to actuate or prevent a specific operation until the system pressure decreases to practically nil. A unique feature is the pressure response element that operates an electric switch at a pressure as low as 0.1 in of mercury above ambient and yet withstands a static pressure of 150 psi. Use of a relay and Micro Switch confines the load on the Micro Switch to the current required to actuate the relay. The company states that the nil-pressure switch



will prove extremely valuable on applications where severe pressure drops endanger lives or the proper functions of machinery. The new switch is compact —6¼ x 5⅜ x 3 5/16 in—and is completely enclosed in a sealed cast aluminum housing. *1.*

Low Pressure, Diaphragm-Actuated Valves

The Emmett Machine and Manufacturing, Inc., announces that a complete line of diaphragm-actuated D-113 Merit valves for almost any type of low pressure service is now available. Valves in sizes from ¼ to 3 in and for maximum pressures of either 300 and 500 psi are included. The new valves can be factory assembled or readily changed in the field for normally open, normally closed or for three-way operation. Exhaust side of the three-way valves is one pipe size large than nominal. Permanent disc and stem assembly, as well as seat rings, are interchangeable in the three assembly types. *2.*

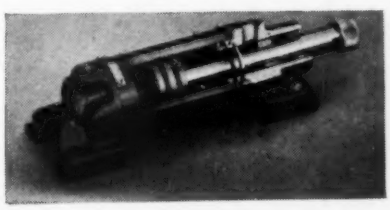
Oil Pilot Valves

A new line of oil pilot valves for remote control of oil pressure operated four-way hydraulic valves is now offered by Gerotor May Corporation.

Operational control in the Series 7000 valves, as they will be designated, is gained by a fork lever design which, when actuated, permits the remote reversing of the main four-way valve. Both fork and hand lever (illustrated) types are supplied. The hand lever permits manual interruption of the cylinder's forward or return stroke at any time. The new pilot valves may be supplied with all ports blocked in neutral, all ports open in neutral and cylinder ports open to exhaust and pressure ports blocked in neutral. Four standard mountings—pipe line, base, foot and panel—are available. *3.*

Hydraulic and Pneumatic Cylinders

Companion lines of hydraulic and pneumatic cylinders for operating pressures of 1500 and 200 psi respectively are announced by the Pemaco Cylinder Division, Petch Manufacturing Co. An important design feature is that an internal snap ring is employed to secure

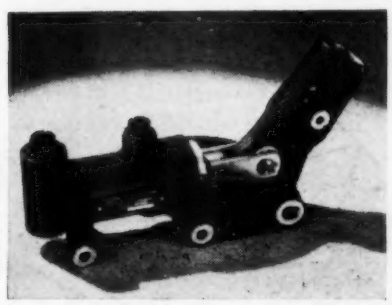


the covers in place, thus eliminating screws, tie rods and external keeper rings and flanges. Pemaco cylinders can, as a result, be used in applications requiring limited space due to their minimum external dimensions. This construction permits unskilled personnel to quickly dismantle and assemble Pemaco cylinders. The piston is attached to the hardened and ground piston rod by an AN approved nut. Rod packing and bushing arrangement is such that packing is not subject to damaging effect of pressure surges. Seven different mountings in bore sizes from 2 to to 10 in are standard. *4.*

CIRCLE NUMBERS ON THE CARD AND MAIL!

High Pressure Hand Pump

A new model 3000 psi hydraulic hand pump of ¾ cu in capacity has been announced by Pacific Division, Bendix Aviation Corporation. The pump, approved as AN-6248-1, is unusually rugged, the body is a permanent mold casting and the forged handle socket is designed to resist extreme side loads as well as high operating loads. The pump employs a double acting piston producing approximately equal volume on the in and out strokes. The Bendix lami-



nated phenolic poppet is used in the integral check valve; these and superoilite bearings assure long life and minimum service. *5.*

Package Electronic Control

A new, completely engineered and prefabricated electronic control unit for use in any type of sequence or process control is announced by Hydraulic Research and Manufacturing Co. Stock plug-in units are available for almost any conceivable sequence of operations, whether it has one or many stages. Any combination may be changed to any other combination of the same number of sequences without internal wiring changes; all operating stages are automatically interlocked and when the sequence is complete it is automatically reset. Each plug-in control unit has a signal light to indicate failure. *6.*

After Cooler

A new model Aero After Cooler, simplified in construction and protected from freezing in outdoor installations, is announced by the Niagara Blower

(Continued on page 34)

HOMEBREW CIRCUITS FO

A shop uses liberal doses of what they call "homebrew" devices to operate individual station mechanisms on a conveyor belt line. One of these, an ingenious combination of mechanical, electrical and air circuits, is used to halt a container, fill it with a liquid, then control its acceleration back to conveyor speed.

By JOHN B. HILL, JR.
Chief Engineer
W. & F. Manufacturing Co., Inc.
Buffalo, N. Y.

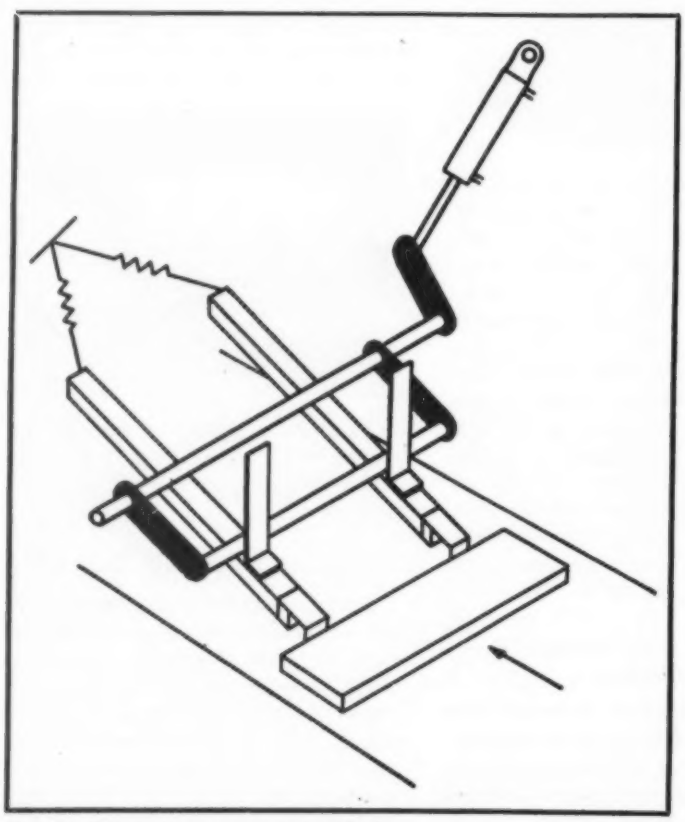


Fig. 1. The arrangement of cylinder operated plunger bars and weighted latches for arresting, then accelerating container travel.

OUR BUSINESS IS THE MANUfacture of novelties. Our company is the leader in its particular field. As in all novelty manufacturing, it is necessary to plan for a short term cost return on all special equipment used. It is necessary, therefore, that the machinery we build be held to a minimum cost and provide maximum efficiency. It must be easily assembled or knocked together but it must be effective—hence "homebrew".

Most of our work is done on continuous conveyors, the various operations being performed on the product units as they pass by or arrive at stations. Sometimes the work is done by personnel seated at the conveyors; sometimes we see an opportunity to have an operation done automatically. In the latter case, it may be necessary to stop the unit long enough to perform the opera-

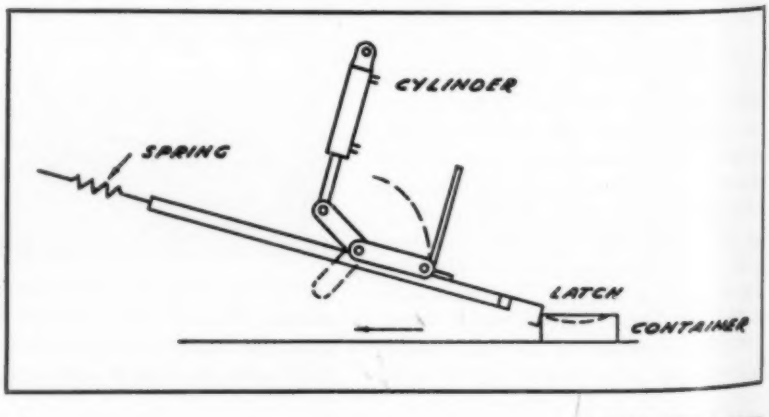


Fig. 2. A side view of the plunger bars, double acting air cylinder, latch and container. During acceleration the latches rise, then ride back across the container and drop into position for the next cycle.

tion, the continuously moving conveyor belt meanwhile keeps sliding under the unit.

This was the case in the operation we will describe. The problem was to arrest the motion of a container as it arrived at the station, fill the container with a liquid, then to release it to be carried away and another container carried into position at the same station. An all-important requirement was to release the container in such a way that its acceleration to belt velocity would not cause spilling of the liquid. The device described below produces a simple harmonic motion from zero velocity to the velocity of the belt.

The apparatus involved a constant speed conveyor belt, an acceleration limiting device which arrested the moving container, held it for the filling operation, controlled or limited its acceleration, then finally released its control at a final uniform velocity. The action, stated simply, is to stop the container under the filling valves, then control the acceleration of the container and release it when it reaches conveyor speed.

The device itself, Figure 1, consists of two plunger bars, on the ends of which are mounted weighted latches. These plunger bars were tilted in their supporting frame slightly upward from the plane of motion of the container, so that on the back stroke, the latches would be contacting the container during the acceleration, release, and on the forward stroke, ride across the container and drop down into place. On the arrival of the next container the cycle repeats. The two plunger bars were driven together "scotch-yoke" fashion; the crank of the drive was operated through a 90 degree rotation by a double acting air cylinder (Figure 2).

A one revolution clutch which drives two cams, one for control of the filling valves and one for operating the air cylinder on the accelerator, controls the timing. In turn, the one revolution clutch was controlled from a micro switch, set by the container itself as it arrives at the proper position for the beginning of the filling cycle.

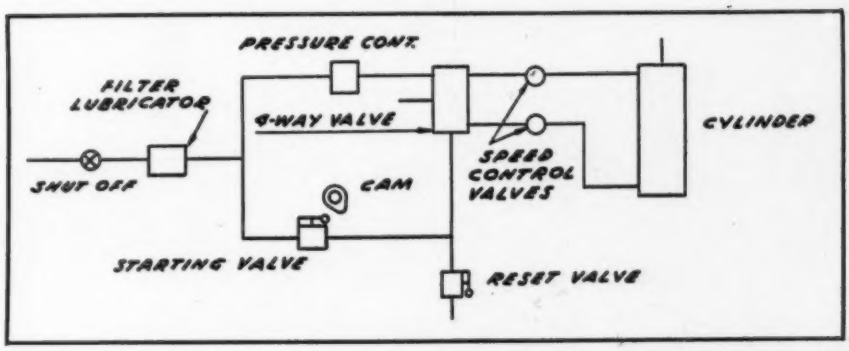


Fig. 3. The air circuit for operating the acceleration limiting device.

Operating Cycle

The cycle was arranged as follows: When the container reaches its correct position for filling, it trips the micro switch, which closes the electrical circuit, engaging the clutch. The filling cam opens the filling valves, releases a measured quantity of liquid into the container and closes the valves. The second cam opens the two-way roller valve, admitting line pressure (100 psi) air to the pilot operated four-way cylinder valve. This cam then allows the two-way roller valve to close, trapping line pressure air in the manifold to the four-way cylinder control valve. The cylinder causes the plunger bars, which are contacting the container, to accelerate and release the container.

When the plunger bars have released the container, the bars open a bleed-off valve in the manifold between the cam activated valve and the four-way control valve, causing the cylinder and the plunger bars to return to their rest positions. The one revolution clutch is timed to complete its cycle before the plunger bars, since it operates only the filling valves and initiates the air cylinder movement. The air cylinder is returned only by completion of its container release stroke.

The cylinder rate of travel is controlled on both the release and return strokes independently by speed control valves (Figure 3) in the cylinder air lines; the total cylinder cycle time is controlled by a pressure regulating valve on the four-way cylinder control valve air supply line. Line pressure is used throughout the four-way control lines to cut down control time lags. A filtering lubricator is installed in the air supply line.

We use air whenever we can. Since our power requirements are not high and our set ups must be kept flexible to meet varying production problems, we have found that combinations of our own mechanical devices, mountings and other homebrew elements with micro switches and air circuits can be consistently counted on to do the job. It means we must keep at least one set up ahead of the jobs we are running, but the long run jobs, such as the one described, have taught us at least some of the things we can do and cannot do; the short run jobs are always planned out and ready to set up as needed.

THE Aldrich Central Hydraulic System illustrated above is installed in a textile belting plant, where it provides hydraulic pressure used in impregnating fabric belts with rubber and in laminating belt sections to produce continuous belting.

By means of the Aldrich-Groff "POWR-SAVR" Controllable Capacity Pump, all of the hydraulic pressure required—*but only that pressure actually needed*—is supplied. This pump automatically controls delivery—in almost direct proportion to demand.

And, by means of the Central System, all hydraulic pressure originates from a single, compact source—affording the least amount of machinery, less maintenance, and quick, easy accessibility. The Aldrich Central Hydraulic System is good engineering —simple, direct, efficient.

For whatever application of hydraulic pressure you may have, and to provide you with pumping equipment that specifically fits your individual requirements—Aldrich builds many types of reciprocating pumps, from the variable stroke "POWR-SAVR" through the constant stroke, constant speed, Inverted Triplex pumps—up to and including the Inverted Nonuplex of 2400 H.P.

For information or for assistance on any pumping problem, write to The Aldrich Pump Company.

Representatives: Birmingham • Bolivar, N. Y. • Boston • Chicago • Cincinnati Cleveland • Denver • Detroit • Duluth • Houston • Jacksonville • Los Angeles New York • Omaha • Philadelphia • Pittsburgh • Portland, Ore. • Richmond, Va. St. Louis • San Francisco • Seattle • Spokane, Wash. • Syracuse • Tulsa

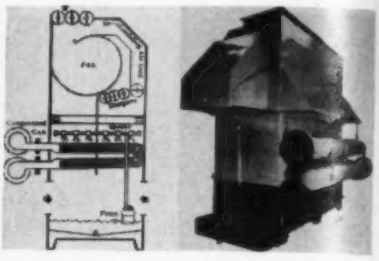
THE ALDRICH PUMP COMPANY

14 GORDON STREET, ALLENTOWN, PENNSYLVANIA

The FIRST *Name in Reciprocating Pumps*

(Continued from page 31)

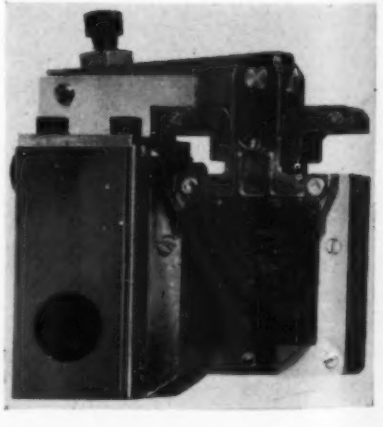
Company. The equipment dehydrates compressed air or gas by cooling it to a temperature below the dry bulb temperature of the atmosphere, removing



the moisture that condenses and preventing further condensation of water in air or gas lines in use. This is done by evaporating a recirculating water spray on the surface of the coil through which the condensed air passes, creating a temperature close to the wet bulb temperature of the ambient atmosphere and lower than the dry bulb temperature and also below the summer surface water temperature. Protection against freezing is given by the use of the "Balanced-Wet-Bulb" control. A thermostat in the spray water reservoir is set for a desired low temperature limit to operate dampers to recirculate the air stream internally around a division plate in the center of the unit. The Aero After Cooler consumes less than five percent of the cooling water required by conventional coolers. *7.*

High Pressure Solenoid Valve

A new inexpensive two-way solenoid valve for hydraulic systems with operating pressures to 3000 psi is announced by Waterman Engineering Company.



Compact in size, the valve is designed for continuous duty, operating on 110 v 60 cycle ac. Poppet type construction eliminates internal leakage and allows full line flow when opened. Oil and moisture resistant impregnated coils makes the valve suitable for mounting in oil reservoirs. The valve, which may be mounted in any position, is available in ⅜ in pipe size. *8.*

APPLIED HYDRAULICS DIGEST

Abstracts, summaries and listings of articles on hydraulic and associated applications in industry; reports on prepared papers, talks and discussions pertinent to the hydraulics field.

Which Hydraulic Pump?

Ransom Tyler, *Machine Design,* v 21, April 1949, pp 141-148.

An excellent, practical comparison of the features of the five basic types of hydraulic pumps—crank and plunger reciprocating, gear or lobe, vane, rotary reciprocating-piston and centrifugal pumps. Each of the chief characteristics to consider in the selection of a pump for a given application are treated in turn: capacity, pressure, input, speed, slip, type of fluid, efficiency, control requirements, durability and reliability, quietness, pulsation amplitude and frequency, size and weight, speed of response, ability to carry peak overloads and cost. There is a table of comparative characteristics of the features of the five basic types.

"O" Ring Friction Characteristics

L. E. Cheyney, W. J. Mueller and R. E. Duval, paper presented at the ASME Annual Meeting, New York City.

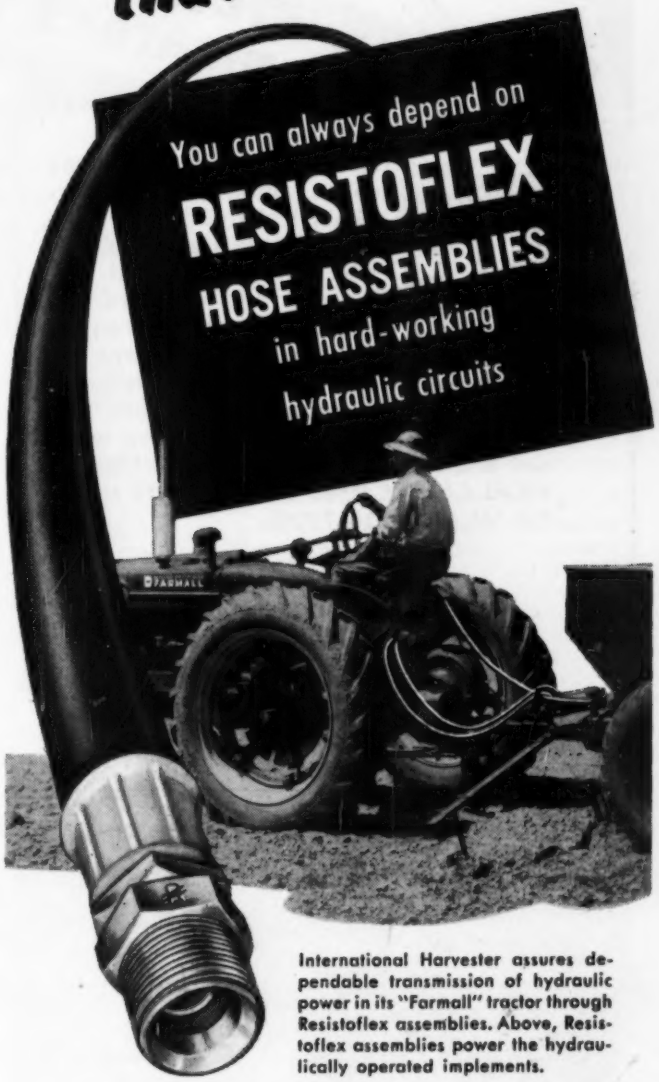
A report on Battelle Memorial Institute project coving the range of AN-P-74 surface finish (5-15 microinches rms) and both below and above this specification to determine the running friction and breakout friction in the range of pressures used in newer aircraft hydraulic systems. Running and breakout friction determinations were made under various conditions of pressure and time delay as well as variations in squeeze. In general, it was found that an increase in pressure resulted in a small increase in running friction and a large increase in breakout friction. Experimental results confirmed the original belief for time delays of less than 40 minutes; longer delays, however, did not appreciably increase the friction. The running friction was almost independent of stroke speed over the range tested. An increase in breakout friction was noted with an increase in stroke speed at 1000 psi, but at other pressures the friction was independent of stroke speed.

Automatic Bending of Digger Links

S. B. Voorhees, *Material & Methods,* v 29, March 1949, pp 61-63.

A specially designed automatic hydraulic bending machine for bending the ends of hot rolled, high carbon steel bars to double U-shaped bends is described. The bars, heated by a radiant gas-fired furnace, are formed

Need a Hose that can take it?



International Harvester assures dependable transmission of hydraulic power in its "Farmall" tractor through Resistoflex assemblies. Above, Resistoflex assemblies power the hydraulically operated implements.

You won't find many applications tougher on flexible hose than a farm implement. Yet, despite the constant movement, vibration and exposure, Resistoflex assemblies don't quit. These top grade lines keep hydraulic circuits functioning at full efficiency—keep a machine on the go. Any time you assure that kind of service, you can take customer satisfaction for granted.

Chances are that Resistoflex lines can do an outstanding job for you, too. Not only are they completely unaffected by flexing and vibration, but they're really impervious to hydraulic fluids and oils too. You run no risk of clogged mechanisms with this non-eroding hose.

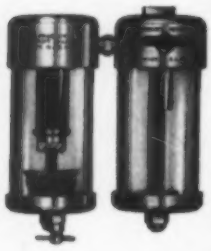
Learn more about why Resistoflex lines insure against excessive replacements and service complaints. Write us about your flexible line problem *today.*

RESISTOFLEX CORPORATION

Belleville 9, New Jersey

SYNTHETIC FLEXIBLE PRODUCTS AND PARTS FOR INDUSTRY

"M-B" AUTOMATIC
Air Line FILTERS and LUBRICATORS



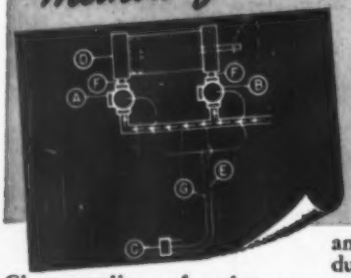
FILTER element removes solids .00039 and larger. TRANSPARENT BOWL provides visibility. LUBRICATOR delivers desired volume of oil, no more, no less. Adjustable Venturi Valve permits efficient operation on broad range of volume and pressure . . . Bowl can be refilled without shutting off air supply. THESE DEVICES CAN BE USED AS SEPARATE UNITS OR IN COMBINATION.

Write for Literature

Representatives in Principal Cities

M-B PRODUCTS
130-134 E. Larned St.
DETROIT 26, MICHIGAN

How to Boost Production with new Method of Mounting Ross Valves



★ Faster Machine Speeds
★ Less Air Consumption
★ Economical Installation
★ Easier Operation

Close-coupling of valve to cylinder! That's the story behind the remarkable success of the *new Ross In-Line Master Valve.*

Users claim several important advantages. By placing the master valves (A & B) at the cylinder (D), air supply and exhaust are speeded up appreciably. This in turn permits faster movement of the cylinder piston and materially increases production.

At the same time, the close coupling means that two lengths of large diameter piping between valve and cylinder — pipes continually filled and exhausted with non-productive air—are replaced by two short connecting pipes (F). The resultant saving in air with every movement of the piston considerably reduces operating costs.

Operation is by a small, conveniently located 3-way pilot valve (C). It is supplied through tubing (E) and connected to the master valves by tubing (G). It may be mechanically, manually or electrically controlled. Hand or foot operation is greatly facilitated by the use of the smaller, more easily actuated pilot model.

For complete details, ask for Bulletin No. 302.

ROSS OPERATING VALVE COMPANY
120 E. GOLDEN GATE AVE., DETROIT 3, MICHIGAN

in two sets of dies, one set making the bends at each end of the rod, in a four-slide operation. When the hot bar is properly positioned, two micro switches, in series, activate the dies and effect the successive bending operations. Each of the successive parts of the cycle are controlled by a camshaft, the cams actuate electrically controlled hydraulic valves, which control the flow of fluid to and from the ram cylinders. Approximately 750 links per hour are produced, the speed permitting immediate quenching without reheating.

Depth and Space Type Filters

D. H. Van Vleck, *Production Engineering,* v 20, May 1949, pp 112-116.

The fundamental principles and considerations that govern the selection of a satisfactory filter for removing harmful solids from liquids in hydraulic and coolant systems are stated and the various types of depth (fiber mass, ceramic and precoats) and space filters (screen, bag, pot, scraper, comb and backwashing types) are discussed as to their advantages and limitations for specific services. The nature of contaminants and the practical economic limit for industrial filtration are discussed. The author reviews the relative merits and demerits of full flow filtration as compared to by-pass filtration on recirculating systems and concludes that a full flow filter of low efficiency can hold down the sludge level in a system better than a by-pass filter of much higher efficiency. He points out that intelligent analysis and the application of fundamental principles can solve any filter problem and that no single type of filter is the answer to all problems.

Fluid Pressure Boosters

Frank Flick, *Product Engineering,* v 20, April 1949, pp 115-119.

The design and advantages of single and double acting boosters or intensifiers, the selection of boosters and typical booster circuits are well treated in this survey article. A selector table and a table of six circuits with operations and limitations detailed should make this of "filing and reference" value to any engineer who has occasion to employ booster circuits in his work. Detailed procedure for selecting a booster is worked out.

Hydraulic Standards Seen Benefitting Metalworking Industry

R. R. Mitchell, *The Iron Age,* v 163, April 7, 1949, pp 100-102.

The advantages of the JIC hydraulic standards for industrial equipment to the machine tools and other industrial equipment into which hydraulic elements and components are incorporated are set forth. Accessibility, reduced manufacturing costs, simplified design, purchasing and operation problems and reduction of maintenance are the major advantages listed. The author, a member of the Production Engineering Section, General Motors Corporation, as secretary of the JIC, has an intimate knowledge of the development of the hydraulic standards. His narrative gives the story of the growth of the standards from a group of master mechanics in GM plants to an industry wide participation and acceptance.

POST SCRIPTS OF INDUSTRY

NEWS · VIEWS · TRENDS

Anker-Holth Mfg. Co., Port Huron, Mich., has appointed Elmer W. Pfeil Inc., Cleveland, as distributor in the Cleveland and Pittsburgh territories.

Valvair Corporation, Akron, Ohio, announces the appointment of Compressed Air Products, 1060 Broad St., Newark, N. J., as exclusive representatives in the northern New Jersey area. Walter Ellis, former sales engineer for Logansport Machine Company and Addison T. Smith, partners in the New Jersey firm, have a total of 24 years experience in the applied air and hydraulic field. The company has a staff of five experienced field engineers.

The board of directors of Marlow Pumps, Ridgewood, N. J., have elected Vincent Vandervoort as vice president.

Lindberg Engineering Company, Chicago, announces the appointment of the Zetterlund Engineering Company of 4385 N. Greenbay Ave., Milwaukee, as their Wisconsin representative for air and hydraulic cylinders and associated equipment.

The Acro Electric Co. of Cleveland, manufacturers of Rolling Spring Snap Action Switches, has been purchased by a Pittsburgh group including Willard F. Rockwell, Jr., president of the Rockwell Mfg. Co.

The Aro Equipment Corporation, Bryan, Ohio, announces the appointment of The Aro Sales & Service, Inc., as its distributor for Aro products on the Pacific Coast. Headquarters will be maintained at 2023 South Grand Ave., Los Angeles, with an office at 766 Brannan St., San Francisco. Sales and service for the

THE MARKET PLACE

CLASSIFIED ADVERTISING

Rates: For "Positions Wanted" $4.00 minimum, limit 25 words. For all other classifications $4.50 minimum for 25 words, each additional word 15c; bold face type or all capitals, $7.50 minimum for 25 words, each additional word 20c; limit 50 words. Box addresses count as five words. All insertions are payable in advance.

These columns are limited to Help Wanted or Position Wanted ads, and offerings of used equipment by the users of such equipment.

RESEARCH ENGINEER — Graduate in engineering or physics for research and development problems in fluid flow, involving water, air, and steam. Man of supervisory caliber with five to ten years experience in experimental techniques and laboratory procedure is desired. Newly equipped laboratory located in Ohio. Send complete details of education and experience in communication to Box 6149, APPLIED HYDRAULICS.

PROTECT HYDRAULIC MACHINES
Where Trouble STARTS!

★ CHIEF ENGINEER
★ HYDRAULIC ENGINEER
★ PLANT SUPERINTENDENT
★ MAINTENANCE SUPERINTENDENT

NO HYDRAULIC CIRCUIT IS COMPLETE WITHOUT
A **MARVEL SYNCLINAL FILTER**
AT THE INTAKE OR SUCTION SIDE OF THE PUMP

Marvel Synclinal Filters are your safeguard against costly breakdowns occuring from pipe scales, dirty oil, and other harmful matter which clogs the fine tolerance valve openings. Why gamble with equipment worth thousands when you may MARVELIZE your hydraulic equipment at a cost that will prove insignificant compared to the price of a jammed or wrecked hydraulic circuit costing thousands.

SUMP TYPE IN 6 CAPACITY SIZES—5 PIPE SIZES.

—5, 8, 10, 30, or 50 gal. per minute. In increased capacity easily obtainable with manifold installations.

Write for Catalog No. 103 containing complete engineering data.

2½ TIMES MORE FILTERING AREA THAN EQUIVALENT SIZE CIRCULAR TYPE FILTERS.

This means maximum filtration in less space. Standard 100 mesh (.0050 opening) insert—others range from coarse 30 mesh to fine 200 mesh inserts. Adaptable to meet any filtering problem.

MARVEL ENGINEERING COMPANY

625 W. Jackson Blvd., Dept. 62 **Chicago 6, Ill.**

Pacific Northwest will be handled by the Pratto Sales Company at 714 Fourth Ave., Seattle, Wash. J. E. Allen, president, L. W. Lisle, secretary and treasurer and W. D. Edwards, vice president, all have had a long association with the Aro Equipment Corporation. Edwards will be in charge of the San Francisco office.

Hydro-Line Manufacturing Co., Rockford, Ill., has appointed two exclusive representatives for their air and hydraulic cylinders and special machinery: the Leaser Engineering Co., LaPorte, Ind., who will handle northern Indiana and the south side of Chicago; the Euclid Machine & Sales Co., 1836 Euclid Ave., Cleveland, whose territory will be northern Ohio.

Hydraulic Press Mfg. Co., Mount Giliao, Ohio, announces the appointment of J. P. Vederko as works manager. Vederko was formerly general superintendent of The Cross Company, Detroit, Mich.

Wade A. Eskridge has been appointed service manager of the Twin Disc Clutch Company, according to an announcement by N. F. Adamson, vice president in charge of engineering and sales. Eskridge will supervise Twin Disc's greatly expanded service program on hydraulic drives and clutches.

Saval, Inc., Los Angeles, announces the appointment of Paul Locklin as western manager of engineering service. Mr. Locklin, formerly Pacific Coast manager for the Parker Appliance Co., replaces J. E. Flickinger, who has resigned to open a sales agency in Dallas, Texas.

The annual meeting of the American Society of Agricultural Engineers will be held at Michigan State College, East Lansing, Mich., on June 20 to 23.

The Hydrabuster Corporation was recently formed in Jackson, Mich., with R. T. Hair, service manager, Joy Manufacturing Co., Peter F. Hurst, president, Aeroquip Corporation and Don T. McKone of the law firm of Bisbee, McKone, Badgley & McInally as directors. Hydrabuster Corporation, a subsidiary of Aeroquip Corporation, has acquired designs and patent rights to a hydraulic devices that dislodges or breaks up coal in large lumps without creating dust.

Index To Advertisers

Aeroquip Corporation ..... Cover 2
Aldrich Pump Co., The 34
American Crucible Products Co., The 40
Bellows Co., The 35
Chicago Rawhide Manufacturing Co. 19
Electrol Incorporated 2
Galland-Henning Mfg. Co. 28
Harrison Radiator Div. 4
General Motors Corporation
Houghton, E. F. & Co. 8
Hydraulic Equipment Co. 1
La Plant-Choate Mfg. Co., Inc. 40
Lindberg Engineering Company, Air and Hydraulic Division 27
Logansport Machine Co., Inc. 36
Marvel Engineering Co. 39
Miller Motor Company 25
M-B Products 38
Niagara Blower Co. 24
Pesco Products Div., Borg-Warner Corp. ..... Cover 3
Plastic and Rubber Products, Inc. 7
Racine Tool & Machine Co. 6
Raybestos-Manhattan, Inc. 5
Resistoflex Corporation 37
Ross Operating Valve Co. 38
Vickers Incorporated 15

Save Real Money

on high quality bronze parts (machined or rough cast) for all types of pumps.

THRUST PLATES
BEARING PLATES
PRESSURE PLATES
BUSHINGS
SEALS
CONNECTING RODS

American Crucible methods, experience, know-how, and equipment spell big savings for you. Furthermore, today's invoices are reflecting declining metal and production costs. Your inquiry can pay you handsomely.

Each part produced from

PROMET
THE Engineered BRONZE

is of the specific bronze formula best suited to the application, thus assuring longer service.
Let us quote you on your requirements and make recommendations as to alloys, best locations for oil grooves, etc. Simply send blueprints, conditions of operation and other data.

THE AMERICAN CRUCIBLE PRODUCTS CO.
1303 OBERLIN AVENUE LORAIN, OHIO

LaPLANT-CHOATE HYDRAULIC UNITS *AVAILABLE NOW* FOR YOUR HEAVY DUTY EQUIPMENT

SEND FOR THIS 16 PAGE BULLETIN TODAY!

It's chuck-full of Construction Details, Performance Data, Dimension Drawings, Installation Data.

Here's valuable information on the complete line of LaPlant-Choate Hydraulic Products . . . hydraulic pumps, motors, valves, cylinders and compact 3-in-1 control units. The LaPlant-Choate Hydraulic line — result of 24 years' experience in building hydraulic controls for our own earthmoving and land-clearing equipment — is now available to provide safe, efficient and economical hydraulic power for your heavy duty equipment. Get the complete story — send for your copy of Bulletin A-1152F.

LaPLANT-CHOATE MFG. CO., INC.
CEDAR RAPIDS • IOWA